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THE GEOLOGIST.

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THE

GEOLOGICAL MAGAZINE

VOLUME LVII.

No. I.—JANUARY, 1920.

EDITORIAL NOTES.

WE must begin the new year by congratulating ourselves that we are alive at all. At one time the outlook was very unpromising, but prospects are now a little brighter, mainly owing to the unremitting exertions of many kind friends, both known and unknown, at home and abroad, to whom the Editors tender their hearty thanks for encouragement and support in a time of need. However, we are not yet out of the wood, and it is obvious that the strictest economy will be necessary for some time to come. It may perhaps be well to point out for the guidance of our contributors some ways in which they can assist in the economy campaign. In the first place the cost of production of plates is now inordinately high, and it may be as well to state definitely that the Magazine cannot afford to publish plates without at least a substantial contribution from the author. We therefore ask our contributors to limit their demands in this respect as much as possible. Again, corrections and alterations in type are now very costly, and much money could be saved if all manuscripts were sent in finally corrected. Occasional printer's errors, though rare in our proofs, are not wholly avoidable, and as to these there is nothing to be said. But it is the alterations of and additions to the text in proof that make the printer's bills mount up. We can assure our readers that with our present circulation the monthly account for corrections is an important item in the balance-sheet.

* * * * *

IT may be permissible here to refer to one or two other matters of internal politics. In the first place it will perhaps be noticed that the present number is printed with a new fount of type, and that the titles of papers have been made rather more bold and conspicuous. Again, the former system of numbering the volumes by Series and Decades has disappeared, having been found too cumbrous. The volume for 1919 is numbered alternatively on the title-page Vol. LVI of Whole Series, and the present one is Vol. LVII. In future references in this Magazine to back numbers before 1919 will be given by the year of publication only, without Series or Decade. Most people have their bound volumes lettered simply with the year, and it requires a complicated arithmetical process to discover

what is meant by, for example, N.S., Dec. V, Vol. VII. It was our original intention to continue the present system to the end of the Sixth Decade, but on further consideration the bolder course of a clean cut appeared to have much to recommend it, and was finally adopted.

* * * * *

THE Non-ferrous Mining Committee continues to hold frequent meetings, and has heard a number of witnesses, who discussed points of interest, especially in connexion with Cornish mining. The general opinion seems to be that in most cases considerable fresh capital is essential for development adequate to meet modern conditions. The outcome, however, depends wholly on the future course of the market for metallic tin. At present prices wolfram appears to be entirely unpayable, and it is regrettable to hear that the very promising Hemerdon mine is closed, after installing new plant on a large scale. The directors appear to be of opinion that the minimum remunerative price is about 55*s*. per unit. At present only one mine is working in the St. Ives district, namely Giew, and that at a loss. It is estimated that to restart the St. Ives Consols group would require an expenditure of £180,000, and it is improbable that so much capital could be raised by private enterprise at this time. Mr. Oliver Wethered expressed the view that the production of the known tinfields of the world could not keep pace with the increasing demand, and was of opinion that high prices for tin would rule for some time to come. With regard to Cornwall, he thought there were possibilities of large production, but considered some immediate help was desirable to stimulate development and to assist in the opening up of new ore-bodies, for the existence of which there is geological evidence.

* * * * *

IT has recently been announced that the Geological Survey of Great Britain has been transferred from the Board of Education to the Department of Industrial and Scientific Research; thus this institution undergoes another mutation in its variegated career. In this connexion it may be permissible to point out that the development of our mineral resources is now under the control of no less than five Government departments. The Home Office is in charge of mines in this country; the Mineral Resources Department formed by the Ministry of Munitions has been handed over to the Board of Trade; the Imperial Mineral Resources Bureau collects information with regard to the Dominions and Colonies; the Imperial Institute, which has done admirable work on similar lines, is under the Colonial Office, while, as before stated, the Geological Survey is now under the Department of Industrial and Scientific Research. These facts suggest that there must be an immense amount of overlap and want of correlation in the different branches, and that it is high time that all these scattered departments were

welded into a coherent whole under one responsible head. We may be allowed to hope that the institution of a Ministry of Mines will not be long delayed. When this comes to pass it is possible that economic and applied geology will gain some of the recognition which is their due, and that the Government geologists may receive salaries commensurate with their high scientific attainments and with the important character of the work so ably carried out by them.

* * * * *

THE water resources of Queensland obtained by boring are of vast importance to that fertile Australian State, and expert testimony upon the conditions underlying this supply is of great interest not only to those who depend upon them for their means of irrigating the country, but also to engineers engaged in supplying the equipment for this natural resource. An artesian expert writing on the subject says: "My experiences with the bores lead me to the following conclusions, which have been proved correct by boring: When years ago artesian bores were first put down it was the custom to drill a hole an inch larger than the casing, so that the casing would go down easily. This has to be done now. When another layer of casing had to be put in it was just lowered down to where the first lot had struck, and drilling continued. When the flow was struck it came up the casing, and it also came up the space around the casing to the higher sand levels. In time this constant friction of the water made the passage much larger, and in consequence the flow decreased. Now this escaping of the waters to these higher sand levels has done an immense amount of good, as it has put large supplies of subartesian waters where none existed before. I have got the records of artesian bores put down which went through huge dry sand drifts. These bores have a diminished flow, but the sand beds are now full of water, and bores being put down all over them give pumping supplies from 10 to 20 thousand gallons per day at a depth of from 80 to 200 feet. Also from these bores there is no waste, and it is easier and cheaper to put down twenty of them, which will water a larger area of country and will not cost as much money as the one artesian bore."

* * * * *

MR. T. W. READER, F.G.S., has been selected by the Geologists' Association as the first recipient of the Foulerton Award. The sum of money which has enabled the Association to make this award is the recent generous gift of Miss Foulerton, in accordance with the wishes of her late uncle, Dr. John Foulerton, who was for many years secretary to the Association.

ORIGINAL ARTICLES.

On an Inverted Mass of Upper Cretaceous Strata near Leighton Buzzard, Bedfordshire; and on an Overlap of the Upper Gault in that Neighbourhood.

By F. L. KITCHIN, M.A., Ph.D., and J. PRINGLE, F.G.S.

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1. INTRODUCTION.

MR. G. W. LAMPLUGH and the late Mr. J. F. Walker published a paper in 1903 on a fossiliferous bed at the top of the Lower Greensand, exposed in sand-pits at Shenley Hill, near Leighton Buzzard.[1] The bed in question presented points of considerable lithological interest and was remarkable for its rich brachiopod-fauna. Its position above the "silver-sands" of the Lower Greensand and below a capping of dark "shaly clay", ascribed by those observers to the Lower Gault, led to the conclusion that it belonged to the top part of the Lower Greensand. The discovery of its fossils was considered to throw welcome light on the faunal characters of the latest Lower Cretaceous rocks in England, represented in more southern counties by relatively unfossiliferous sands.

The fauna of this bed of limestone-lenticles raised questions of much interest. While there was apparently an admixture of Lower Cretaceous and Upper Cretaceous species, a considerable number of the fossils present in the bed constituted an association of species known in England only from the lowest part of the *varians* zone, the basal Cenomanian as understood in this country. Such were the large form of *Terebratula biplicata* J. Sow., *T. ovata* J. Sow., *Terebrirostra lyra* (J. Sow.), *Rhynchonella grasiana* d'Orb., and *Rh. dimidiata* (J. Sow.); also the echinoids *Cardiaster latissimus* Ag., *Catopygus columbarius* Lam., *Echinobrissus lacunosus* Goldf., and *Pyrina laevis* Ag. These and other elements of the fauna appeared to contradict the interpretation offered by Messrs. Lamplugh and

[1] G. W. Lamplugh & J. F Walker. "A Fossiliferous Band at the top of the Lower Greensand near Leighton Buzzard": Quart. Journ. Geol. Soc., vol. lix, 1903, p. 234.

Walker, whose reading of the facts implied an anomaly so arresting as to make further investigation desirable. Nevertheless, those authors were more impressed by the stratigraphical evidence, as understood by them, and remained convinced that the bed occupied a normal position below the Gault. They met the difficulty by explanations which we have always considered to be inadequate,[1] while they treated as so-called "varieties" some of the species which appeared to occur so far below their usual horizon. Arguing from stratigraphical inferences, they claimed to demonstrate that these species in reality made a much earlier appearance and possessed a much longer vertical range than had previously been suspected.

We need make no lengthy comment here on this manner of dealing with the palæontological aspects of the bed; but we desire to record that from the first we have entirely disagreed with the interpretation given. It has always appeared clear to us that if the bed contains both derived and indigenous fossils its geological age must be that of its latest species. To assume such an early appearance and long persistence for the particular assemblage of brachiopods and echinoids mentioned, has always seemed to us to be making an arbitrary use of the fossil-evidence. Some biological considerations which are in conflict with the assumption need not be entered into here. The zonal significance of these fossils had been firmly established by the well-known facts of their restricted occurrence both in this country and on the Continent. Hence it appeared a hazardous proceeding to ignore the indications they afforded and to place more reliance on stratigraphical appearances.

In subsequent years the above-mentioned authors collected additional fossils from the limestone-lenticles with brachiopods, resulting in further support for our opinion that the true position of the bed is at the base of the Cenomanian. Mr. H. Woods has kindly communicated to us the names of some species represented in the collection obtained by Mr. Walker, now preserved in the Sedgwick Museum, Cambridge. They include the brachyurous crustacean *Cyphonotus incertus* Bell, first described from the so-called "Upper Greensand" of Horningsham, Wiltshire. The type probably came from some exposure in the basal part of the Cenomanian, at which horizon the species is found at other localities in Wiltshire and in Somerset. This fossil also occurs in the Cambridge Greensand. Mr. Woods points out to us that no earlier species of this genus is known. The lamellibranchs at Cambridge include *Pecten* (*Camptonectes*) *curvatus* Geinitz, which occurs in the Upper Greensand of Great Haldon and in the Chloritic Marl, and *Cyprimeria* (*Cyclorisma*) *rotomagensis* (d'Orb.), a species of the basal Cenomanian of Wiltshire. Among the lamellibranchs found in the limestone by Mr. Lamplugh and presented by him to the Geological Survey occurs *Isoarca obesa* (d'Orb.), which is not known elsewhere from below the Chloritic Marl. We have ourselves collected

[1] Op. cit., pp. 247–9.

Lima globosa J. de C. Sow., the type of which came from the Chloritic Marl. This species has also been recorded from lower horizons, but has not been found below the Gault.

After the publication of the account of the section, Mr. Lamplugh collected some fossils from an inconstant layer of green sand, attaining in one place 5 feet in thickness, found to be intercalated between the limestone-lenticles with brachiopods and the Gault above. The specimens comprised nothing to indicate a Lower Greensand or Lower Gault age, but Mr. Lamplugh was nevertheless inclined to correlate the deposit with the *mammillatus* bed at the base of the Gault.[1] These fossils included well-developed valves of *Ostrea vesicularis* Lam., such as are found in the zone of *Pecten asper* Lam.;[2] also *Ostrea canaliculata* (J. Sow.), a species which occurs much more commonly above the Gault than below it. There were numerous specimens of *Serpula antiquata* J. de C. Sow., a common fossil in the *Pecten asper* zone of Wiltshire. A few associated cirripede-remains were later studied by Mr. T. H. Withers, who kindly furnished us with some notes upon them. He reported that a scutum and a carina must be referred to *Pollicipes glaber* F. A. Roem., and that agreement is closest with specimens from the Chalk Marl. The carina has a narrower base than that of *P. unguis* J. de C. Sow., from the Gault of Folkestone. Another specimen is a scutum which may best be compared with *Pycnolepas rigidus* (J. de C. Sow.), "although it is in some respects rather more advanced in certain characters than the typical valves of that species." *P. rigidus* occurs in the Gault, and Mr. Withers believes that the more advanced evolutionary characters shown by the valves from Shenley Hill indicate a later geological age. He points out that nothing is known from below the Gault with which any of these remains can be compared, and he considers that they furnish evidence that the sand in which they occurred is newer than the Gault.

It is important when considering this disputed question of age to look into the literature dealing with the faunas of the zones just prior to the *mammillatus* bed, as developed on the Continent; that is to say, the *Belemnites strombecki* beds in Brunswick (with the zone of *Leymeriella tardefurcata* at the top) and the Clansayes zone of South-Eastern France. It becomes more than ever clear that the life of that time resembles in no manner that of the brachiopod-bed at Shenley Hill, supposed to be of comparable age. Indeed, this bed furnishes such strong faunal links with the "Cornstones" of Wiltshire and contiguous strata[3] as, in our opinion, to leave no

[1] "Excursion to Leighton Buzzard": Proc. Geol. Assoc., vol. xx, pt. vi, 1908, p. 475.

[2] H. Woods, *Monograph of the Cretaceous Lamellibranchia of England*, Pal. Soc., vol. ii, pt. ix, 1913, figs. 143–5, p. 367.

[3] A. J. Jukes-Browne, *The Cretaceous Rocks of Britain*, vol. ii, "The Lower and Middle Chalk of England" (Mem. Geol. Surv.), 1903, p. 148. A. J. Jukes-Browne & J. Scanes, "The Upper Greensand and Chloritic Marl of Mere and Maiden Bradley, in Wiltshire": Quart. Journ. Geol. Soc., vol. lvii,

room for doubt. It is in the bed below the "Cornstones" that ammonites of the *varians* fauna first begin to make their appearance. The lenticles of brachiopod-limestone at Shenley Hill may be correlated most appropriately with the basal Cenomanian, which Jukes-Browne tabulated as the sub-zone of *Catopygus columbarius*. No other construction can be placed on the combined testimony of associated species representing four animal-classes.

We need press the palæontological argument no further. There is a corroborative circumstance of much interest. The lithological constitution of the limestone-lenticles, so well described by Mr. Lamplugh,[1] is of a peculiar and distinctive type not matched elsewhere in this country, so far as we know. But the basement-bed of the Chalk (*varians* zone) at Matringhem, Northern France, shows a remarkable similarity of characters. Although samples of the rock from Shenley are as a rule distinguishable by their ferruginous staining, the resulting difference is merely of a superficial kind; and it is possible to select specimens which are inseparable from examples of the Matringhem bed except by the aid of their labels.

In the year 1918 a review of all these considerations served to confirm our previous opinion that an error had been committed; and since Mr. Lamplugh's reading of the section had been accepted by other experienced geologists who had visited the locality, we concluded that the stratigraphical aspect of the series exposed at Shenley Hill must be of a most deceptive character. In the hope of securing data upon which to base a sound interpretation of the succession, we examined the ground in October, 1918, and collected fossils, first of all from the supposed Lower Gault overlying the brachiopod-bed. Since then we have paid numerous visits to the district and have searched for fuller information bearing on the question at issue.

A consideration of the stratigraphical, lithological, and palæontological evidence thus obtained has led to the conclusion that in the sections at Shenley Hill where the masses of brachiopod-limestone have been found, these lenticles, the inconstant layer of green sand above them and the overlying Gault Clay, are in an inverted order of succession. The overturned mass of strata does not in itself form a complete unbroken series. There is definite evidence of one non-sequence within it, and there may be a second one. We are also able to show that the strata upon which the inverted beds now repose do not constitute a simple conformable series. The top of the Lower Greensand is here overlain unconformably by the basal bed of the Upper Gault, which in the neighbourhood of Shenley Hill lies transgressively upon older strata.

1901, p. 96. J. Scanes, in Report by B. Pope Bartlett & J. Scanes, "Excursion to Mere and Maiden Bradley, in Wiltshire": Proc. Geol. Assoc., vol. xxvii, pt. iii, 1916, pp. 122–5.

[1] Op. cit., pp. 241–2.

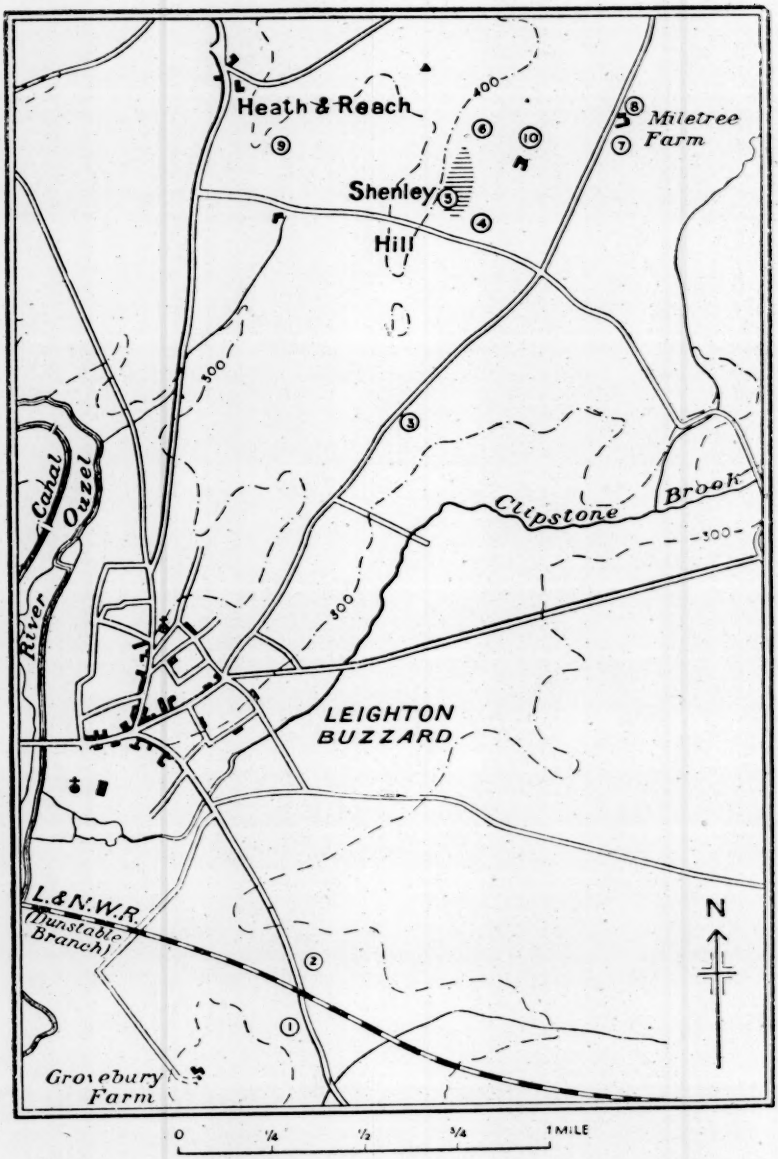

Fig. 1.—Sketch-map to show the positions of the sections described. The map is adapted from the 1 in. Ordnance Survey map. The numbers indicate the position of localities referred to in the text. The shaded patch at locality No. 5 represents the estimated former extension of the inverted mass of strata in worked-out areas in the sand-pits.

2. The Section.

The only section showing all the above relationships at the present time is that exposed in the sand-pit of Mr. Gregory Harris (No. 5),[1] to whose kindness we are indebted for permission to collect at that locality. The main features of this striking exposure have been described by Mr. Lamplugh, whose account of the strata may be summarized as follows, from his description of the succession seen at the northern end of the pit (op. cit., Fig. 3, p. 238).

In descending order, below 1 foot of soil :—

A.	Bluish-grey Boulder-clay	2–6 feet.
B.	Gault : bluish-grey shaly clay above, dark-blue below .	4–7 feet.
C.	Irregular band of iron-grit	1–3 inches.
D.	Ochreous or greenish-yellow loamy sand, grit, and breccia ; replaced here and there by lenticles of pale flesh-coloured or yellowish gritty limestone, full of fossils [the brachiopod-bed]	1–2 feet.
E.	Undulating iron-grit band	2–3 inches.
F.	Greyish loamy greensand, with clayey streaks and lenticles of pebbly grit	2–3 feet.
G.	Lenticles of dark-red and ochreous iron-grit, with small included nodules of sandy pyritous claystone ; streaks of fuller's earth, dark clayey greensand, and ochreous loam below ; forming a well-defined band capping the "silver-sands"	1–1½ feet.
H.	"Silver-sands," strongly cross-bedded	10–15 ft. seen.

Mr. Lamplugh gave a full account of the lithological characters of beds D and H, which, with the intervening strata, he ascribed to the Lower Greensand. He also dealt at some length with the bands, described by him as "iron-grit", C and E. The section as exposed in October, 1918, was substantially the same as in 1903, though during the working back of the pit into the slope of the hill the thickness of the Gault had increased to about 10 feet. The Boulder-clay on the other hand had become reduced in thickness. Early in 1919 an extensive mass of Gault Clay slipped down into the pit and obliterated the whole exposure ; but during the past summer the work of re-excavation has proceeded rapidly, so that the section can again be studied at the southern end of the pit. A result of the slip was to render the Gault accessible for examination up to about 18 feet from its base, where it now shows a capping of Drift so inconsiderable as to be scarcely distinguishable from the soil.

A first glance at the section shows an apparent continuity within the series of beds situated above the "silver-sands" and below the Drift. These strata are separated from the cross-bedded sands below by a well-marked plane of division, having the appearance of an unconformity. Mr. Lamplugh drew attention to this line of demarcation, but ascribed to it a minor importance. He wrote : "This line of junction seems to form a definite floor and to imply some degree of erosion and unconformity. Yet in a mass so

[1] The numbers thus quoted in parentheses are the reference numbers showing the position of localities on the sketch-map, Fig. 1.

irregularly bedded as the Lower Greensand such appearances are not unusual and need not necessarily denote anything more than local erosion and rearrangement."[1] We believe this suggested interpretation of the break to be correct.

Continued excavation during the period covering our visits has shown much variability in the character and thickness of beds D, F, and G. Bed F may be absent, and G may become locally

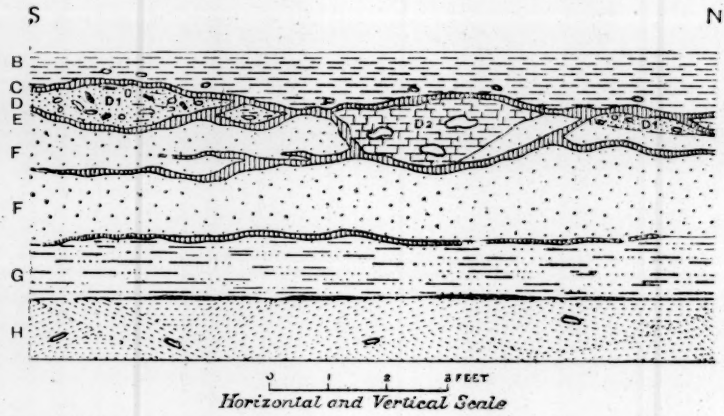

FIG. 2.—Diagram to illustrate a part of the beds seen in the working-face of Harris's Pit, Shenley Hill.

The representation is given in simplest diagram form. It reproduces a part of the section actually seen, where the relations of the beds D and F are less confused than is frequently the case. The clayey sand F is present here in fuller development than in other parts of the section exposed at the same time, where the inverted Gault Clay approached closer to the top of the "silver-sands" and the material of bed D_1 was more continuous and was in places in contact with the sand bed G.

The letters are those used by Mr. Lamplugh to distinguish the successive beds. The lenticular masses of Mr. Lamplugh's bed D are here marked D_1 and D_2 for the purpose of distinction. According to the reading of the evidence adopted in this paper the age and relations of the strata are as follows :—

B. Inverted top part of the Upper Gault of the neighbourhood. Only a portion of the inverted mass is shown.

C and E. Irregular bands of limonite-ironstone, developed along the surfaces of stratigraphical discontinuity and those of more ready permeability caused by disturbance of the strata. Where the topmost band separates the Gault from the limestone-lenticle D_2 it occupies a surface of non-sequence.

D_1. Remnants of the basal bed of the Upper Gault in situ, resting unconformably upon the Lower Greensand.

D_2. Inverted lenticular limestone-mass with brachiopods, a remnant of the basal bed of the Cenomanian stage formerly present in the neighbourhood.

F. Imperfectly bedded clayey sand of the Lower Greensand, of pre-*tardefurcata* age.

G. Well-bedded fine sand with thin lenticles of carbonaceous clay and lignite at the base : Lower Greensand

H. False-bedded "silver-sand" of the Lower Greensand ; only the upper part shown.

[1] Op. cit., 1903, p. 239.

reduced to a few inches in thickness, while the two may be observed to swell out, only a few yards away, to a thickness of fully 4 feet. The appearance of inconstancy in the strata between the "silver-sands" and the Gault Clay is increased by the lenticular character of the variable masses forming bed D, present in one part of the section while absent in another. (See Fig. 2.)

We have never seen the "dark-red and ochreous iron-grit" in bed G, described by Mr. Lamplugh as occurring in lenticles. Whenever examined by us bed G has consisted of horizontally bedded grey, black- and green-streaked carbonaceous and clayey sand in thin layers, with purer streaks showing a closer approach to the character of the underlying silver-sand, from which the sandy constituents of the bed have apparently been derived. The sand of this bed, particularly in some of the layers, is of an exceptionally fine, smooth texture. At the base, immediately overlying the "silver-sands", there are local patches of carbonaceous clay with much lignite. These are about 2 inches in greatest thickness and may attain a length of 5 feet. We have obtained flat pieces of lignite up to 6 inches in length from this basal layer of bed G. An inconstant seam of limonite-ironstone, varying from 1 to 2 inches in thickness, is present at the junction of beds G and F. It occurs in the form of isolated lenticles varying from 2 to 9 feet in length.

The thin ironstone-bands (C and E), following an undulating course above and below the lenticular masses of bed D, display much irregularity. Mr. Lamplugh has described how they sometimes approach one another, so that they almost meet. We have seen them again and again enveloping the lenticles of limestone and brecciated material of bed D and becoming actually confluent. The lenticular enclosures thus formed may occasionally include a little of the sand of bed F. We have noticed also that the lower ironstone-band, E, frequently gives off branches which pass down obliquely into bed F, and sometimes become joined to a thinner inconstant layer of similar ironstone which occurs here and there with almost horizontal disposition within that bed (see Fig. 2). From these relations we conclude that the bands of ironstone form no original part of the beds with which they are now incorporated, but are of subsequent development. As will presently be shown, no other conclusion is possible in view of the fact that beds D and F are not in normal sequence and are of widely different age. The nature of bed D alone is such as to disprove the contemporaneous origin of the ironstone-bands. The bands themselves, occupying a position along the surfaces of more ready permeability, are composed of limonite, somewhat cavernous in places, with a varying amount of included sand. Where they occur within a sand, as in bed F, they may contain much of the same material. A specimen taken from between a limestone-lenticle of bed D and the Gault Clay above, contains scattered sand-grains no more numerous than the grains within the limestone, which the limonite has partly

replaced. But the purity of the limonite varies much, even within the sandy strata. We do not consider that Mr. Lamplugh's term "iron-grit", as applied to these bands, is quite happily chosen.

Bed D, which contains the lenticles of brachiopod-limestone, is of a complex character; it may be more conveniently discussed on a later page in the light of information obtained at other sections. Its confused aspect is the result of a remarkable collocation of heterochronous elements. While the lenticles of brachiopod-limestone belong to the basal bed of the Chalk, there are other lenticles of sandy clay, often with rounded grit-grains and pebbles, which contain angular or subangular fragments and rounded pebbles of ironstone; these masses, together with some patches and streaks of yellowish sandy and earthy-looking clay, are remnants of the basal bed of the Upper Gault. The separate lenticles of diverse origin and age are brought into juxtaposition in such a manner as to appear as if they had originally occupied the same general plane below the base of the Gault Clay in this section; and they have acquired a certain spurious resemblance to one another as a result of secondary ferruginous staining.

Other points must be noted here, the significance of which will appear in our further discussion of this composite bed. In the lenticles and streaks belonging to the base of the Upper Gault we have seen occasional small white calcareous nodules. In one of these irregular streaks we found a flat pale-brown claystone nodule, the source of which, in a stratum of pre-*interruptus* age, can be traced in another section. The lowest two or three inches of the Gault Clay, in contact with the limonite-sheet overlying bed D, are in some parts shaly and fissile in the horizontal direction, and are stained to a reddish hue.

3. The New Evidence.

Neighbouring exposures, where the lenticles of brachiopod-limestone are absent, reveal varying stratigraphical relationships which have an important bearing on the interpretation of the section at Harris's Pit. The Gault Clay in these other sections, when present, is not the same Gault, either lithologically or palæontologically, as that forming the 18 ft. mass above the brachiopod-bed in Harris's Pit. Indeed, the clay and the brachiopod-limestone of bed D in that section are quite local and narrowly circumscribed in their occurrence, a point which we shall presently emphasize. We soon recognized that an important break in the succession occurs there below the brachiopod-limestone.

The fossiliferous limestone-lenticles, which had already received so much attention, seemed to speak for themselves and to require no further palæontological study; hence it appeared advisable in the first place to examine the credentials of the supposed Lower Gault above. Fossils were collected from it at successive levels, and a comparison was made with the Gault seen in normal position

above the Lower Greensand in pits near Leighton Buzzard, and also in pits adjacent to Harris's at Shenley Hill, as well as in others further away to the east and west of the hill. The study of these sections enabled us, at the same time, to identify the beds between the "silver-sand" and the brachiopod-limestone at Harris's Pit. Finally, information was sought as to the succession of beds between the Gault and the Chalk Marl along the base of the Chalk escarpment, some miles to the east and south-east.

A. Characters and Correlation of the Gault in Mr. Gregory Harris's Pit.

It is a matter of surprise to us that this clay has ever been mistaken for Lower Gault. Its lowest part shows a pronounced marly character, and differs from the true Lower Gault of the district by the absence of sand and the rarity of glauconite :- it yields none of the ammonites of the Lower Gault, but contains species characteristic of the *rostratus* zone.

To confine attention first of all to the lowest 8 feet. The well-bedded rock above the lowest few inches has a blocky or sub-conchoidal fracture ; it is of a very dark-greenish grey hue when wet, but dries to a much paler colour. Though strongly argillaceous, it contains a considerable proportion of carbonate of lime and it shows minute glistening specks, which at first suggest that it is somewhat micaceous. This appearance is due to tiny flakes of carbonate of lime, probably derived from the thin friable shells of a species of *Anomia*.

With the exception of *Belemnites minimus* List., which is found fairly abundantly a short distance above the base, fossils are not easily obtainable in a state fit for identification. *Inoceramus* is not uncommon, and there are apparently at least two species, one of which is a flattened expanded form suggestive of *I. crippsi* Mantell. Neither *I. concentricus* Park. nor *I. sulcatus* Park. has been found in the lowest 8 feet, although prolonged searches have been made. The presence of small impressions of the characteristically ornamented *Nautilus deslongchampsianus*, d'Orb., indicates a position in the *rostratus* zone or higher. This species has been recorded from the Upper Greensand of Wiltshire (*rostratus* beds and *Pecten asper* beds), but it is more distinctive of the Chalk Marl. Ammonites occur in a band which, in different parts of the section, varies in position from 2 feet to about 4 feet above the base of the clay. They are poorly preserved, in a compressed condition, often consisting of little more than brownish rusty films on the bedding-surfaces ; nevertheless, many show plainly the main features. The commonest form is closely comparable with well-known specimens from the sandstones (*rostratus* zone) of the Upper Greensand of Devizes and of the Undercliff, Isle of Wight, variously named in museum collections as *Hoplites auritus* (J. Sow.), *H. catillus* (J. de C. Sow.), or *H. auritus* var. *catillus*.

These well-known ammonites have not been adequately studied, and their relationships remain to be ascertained. They are discoid in form, and are characterized by strongly curved ribs and the loss of these ornaments in the later growth-stages, during which, however, traces of the flattened, swollen rib-endings on either side of the smooth, narrow peripheral area continue to be shown. The naming of these distinctive forms is of little importance in the present connexion ; it is sufficient to say that they are members of an easily recognizable hoplitid group which have reached an evolutionary stage characterized by degeneration of the sculptural features. The significant point is that they give us an important datum-line. A specimen of one of them from the Upper Greensand near Devizes has been kindly examined for us by Dr. B. Pope Bartlett, who, after discussing the matter with Mr. J. Scanes, has expressed the opinion that it came from a position about 60 to 80 feet below the base of the Cenomanian stage. This is in the *rostratus* zone, and the similar specimens from the Isle of Wight came from the sandstones underlying the Chert Beds on a corresponding horizon.

Among other fossils found in the lower part of the clay at the locality we are discussing are *Nucula pectinata* J. Sow., *Pecten* (*Syncyclonema*) *orbicularis* J. Sow., and "*Scalaria*" *dupiniana* d'Orb. ; but these are valueless in settling the question of age, since their range extends up from the Gault into and above the zone of *Pecten asper*. At about 8 to 10 feet above the base of the clay further ammonites were found. These include a *Hoplites* of the *tuberculatus* group, and another well-tuberculated species showing smooth late growth-stages ; also a large involute hoplitid of flattened discoid form, devoid of ornamentation and with narrow concave peripheral area. This appears to represent an advanced evolutionary stage in one of the several series whose members are commonly united under the favourite collective name *H. splendens*. At this level and in the overlying part of the clay there occur large crushed examples of *Inoceramus sulcatus*, Park., a fact of much significance.

At about 15 to 17 feet above the base these *Inocerami* are associated with numerous ammonites, including an undescribed *Schloenbachia*, characteristic of the *rostratus* beds, *Schloenbachia varicosa* (J. de C. Sow.) [= *Hysteroceras* of Hyatt], and several species of *Mortoniceras* (the keeled ammonites of the *rostratus* group, *sensu lato*), including at least one belonging to the narrower group of *M. inflatum* (J. Sow.). This association of forms, particularly the abundance of *Inoceramus sulcatus* and *Schloenbachia varicosa*, points to a position in the *rostratus* zone corresponding with Price's Bed IX at Folkestone.[1] This upper part of the clay is rather more limy, and on drying becomes paler in colour than the lower part. The fact that the Upper Gault along parts of the Bedfordshire outcrop shows resemblance to the Chalk Marl has been frequently commented on.

[1] F. G. Hilton Price, *A Monograph of the Gault*, London, 1880, p. 20. "On the Gault of Folkestone" : Quart. Journ. Geol. Soc., vol. xxx, 1874, p. 351.

From the above observations it is seen that no part of the Gault in this pit can be placed lower than the *rostratus* beds. The character and distribution of the fossils lead us to conclude that the upper part of the clay belongs to a lower zonal level than the lower part. Elsewhere *Inoceramus sulcatus* and *Schloenbachia varicosa* are common in the lower part of the *rostratus* beds, absent in the higher part. At Harris's Pit these relations are reversed. If the absence of these fossils from the lower beds there might be thought to indicate that these strata represent the Lower Gault, this is contradicted by the positive evidence of the fossils present and by the absence of any characteristic Lower Gault species. Bearing in mind that the brachiopod-bed, which here underlies the Gault, contains a fauna characteristic of a still later geological date, the facts already set forth seem explicable only on the assumption that the series here exposed is in an inverted position.

It must be noted that the zonally highest Gault seen in this section, that is to say the lowest part of the inverted mass of Gault, is not of sufficiently late age to be succeeded immediately by the basal bed of the Cenomanian stage in a series where there is no zonal break. There is evidently a chronological gap and stratal non-sequence of some magnitude between the clay and the brachiopod-limestone of bed D. The bed of green sand sometimes intercalated between these strata, once seen by Mr. Lamplugh in the contiguous Garside's Pit, provides evidence of the former existence of the connecting deposits. Its faunal and lithological characters, as well as its position, can leave little doubt in our minds that it belongs to the zone of *Pecten asper*, which may have had ample representation here prior to the period of erosion marked by the basal Cenomanian bed. We have never had the good fortune to see any of this green-sand in the present section. It appears, however, to have been met with many years ago in Harris's Pit, when the working-face was situated farther to the east, as well as in Garside's Pit, where it was laid bare between the years 1904 and 1906. The junction between the Gault Clay and the intermediate remnant of the Upper Green-sand may itself form a line of earlier non-sequence than that shown by the direct contact between the clay and the basal Cenomanian bed. On this point, however, there is at present no conclusive evidence. The facts as we have sketched them provide a simple explanation of the relations between Gault and basal Cenomanian in this section, and one which is wholly in accord with the established principles of zonal determination and correlation. We shall now show that this reading of the evidence obtained at Harris's Pit is amply supported by a comparison with other sections.

(*To be continued.*)

Pre-Triassic Swallow-holes in the Haematite District of Furness, Lancs: a Glimpse of an Ancient Landscape.

By Bernard Smith, M.A., F.G.S.

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A POINT of economic importance, as well as scientific interest, has been brought out by a study of the occurrences of hæmatite in the Furness district of Lancashire and the neighbouring shores of the River Duddon in the Millom district of Cumberland; namely, that the origin and distribution of the ore-bodies, known as "sops", is due, in large measure, to the physiographical conditions that existed in this area in post-Carboniferous but pre-New Red times. Future explorations for these profitable ore-bodies may be guided by a true appreciation of the conditions of formation, which are discussed, in somewhat scattered form, in the recently published Geological Survey Memoir [1] on the "Hæmatites of West Cumberland, Lancashire, and the Lake District".

The following is a more connected resumé of the events that gave rise to the sops and the reasons for their restricted occurrence.

We may preface our remarks by stating that (1) the hæmatite found in the Carboniferous Limestone, both in Cumberland and Furness, is due to a metasomatic alteration of the Limestone, presumably by the descent of iron-bearing solutions stored in the New Red beds that overspread the Carboniferous rocks; and (2) "sops" may be defined as bodies of ore, circular to oval in form, and narrowing downwards irregularly like deep basins or pockets in limestone.

It appears that in pre-New Red times the main mass of Carboniferous Limestone formed a widespread plateau extending from near Kirksanton, north-west of Millom in Cumberland, eastward to near Lindal-in-Furness, and was dominated on the south by a northward-facing escarpment of Yoredale Beds. South-west of Dalton-in-Furness the escarpment looped southward to near Yarlside and Stank, as a sharp V-shaped notch, the eastern wall of which was a pre-New Red fault-scarp trending from north to south.

At the present day swallow-holes and caverns are abundant on such limestone plateaux, and as fast as the swallows go out of commission, or the cavern-roofs collapse, they become choked with débris, mostly of an angular and open character, and occasionally roofed with turf. So also in this case swallows were formed, and when a hole ceased to serve as an open conduit, material falling from the walls filled the bottom with coarse limestone débris, and included masses of limestone-shales. Disintegrated shale and mud, washed in, formed a rough lining to the whole mass, and in some cases formed a clayey plug at the bottom. The foot of the escarpment, also, became the depository of screes or brockrams as

[1] Special Reports on the Mineral Resources of Great Britain, vol. viii, 1919.

the escarpment slowly receded under the action of weathering agents.

In New Red times both the plateau and escarpment were overspread by characteristic deposits of dolomitic limestone and breccias (both local), red sands, clays, and shales, relics of which still survive in several places, even where there has been great denudation. In the Newton and Yarlside Mine, in the V-shaped notch above mentioned, the old pre-Triassic fault-escarpment has the irregular outline of a present-day limestone cliff, with the New Red Sandstone still banked against it.

At some post-Triassic date the area was upheaved, faulted, and subjected to denudation.

Since the uplift the Yoredale Beds have been worn back by erosion almost 2 miles to their present position near Adgarley and Little Urswick. Farther south they have retreated less. Towards the Duddon shores they are faulted down beneath New Red Sandstone and do not appear at the surface.

The uplift further resulted in the downward movement of iron-bearing waters, which attacked the limestone-breccias in the swallows and caverns, or the limestone along faults and joints.

The mineralizing solutions, entering from above, were concentrated chiefly upon the limestone-breccias, which by nature are peculiarly vulnerable. As the alteration of the limestone fragments progressed the masses of newly formed ore packed together and led to the collapse of the roof and let in the overlying New Red sands and loams in jumbled masses. This episode is recorded in the irregular pockets of such material that are found in the ore of the Park and Roanhead Mines.[1]

That the above is probably the true story receives confirmation from the following facts: (i) After removal of the ore the limestone walls, in some cases, show a smoothing that is characteristic of the action of water, and presumably was effected before the ore was formed. (ii) The sops are lined with "hunger" and "muck". The former is partly composed of weathered shale like that interbedded with the limestone, while the "muck" is probably derived from the ore itself. (iii) Patches of limestone shales are found embedded sporadically in the pure ore. (iv) The ore in the centre of each sop is good soft pick-ore, in small fragments, just such as would be formed from a loose breccia that packed together during alteration. (v) Lastly, a mass at least 122 feet in thickness near its centre, composed of *chocolate-coloured clay like a cave earth*, and containing many subangular waterworn fragments of limestone, has been found recently, filling the bottom of the Nigel Pit sop at Roanhead, *beneath the main mass of ore*. It also contains small sandstone fragments and patches of hunger and muck.

In Furness, therefore, the area in which "sops" may be expected

[1] Summary of Progress for 1916: Mem. Geol. Surv., 1917, pp. 9–10.

to occur is constituted by the limestone-plateau, some 7 to 8 square miles in extent, north of the old Yoredale escarpment.[1] To the south and east of the escarpment the ore occurs usually only in vein-like form, and the existence of large bodies of ore becomes less probable with increased distance from the escarpment and a correspondingly increased thickness of cover of Yoredale Beds, which acted as a screen between the iron-bearing solutions and the limestone.

Ore in sop-like form is also likely to occur in the Limestone beneath the Duddon Sands north of Sandscale, and to a less extent perhaps in the Millom area north of Haverigg.

In the sop area (excluding the Duddon shores, where exploration is proceeding) the ore-bodies usually come up to the surface, or to the base of the Glacial drift, and presumably most of these (somewhere near 100) have been located. Some, however, may have remained undetected in the belt where both sops and "veins" occur most freely—i.e. on the line of the foot of the old Yoredale escarpment from the south-east of Dalton as far as the Lindal–Whinfield district. Moreover, some of the old mines might pay to reopen, for they were abandoned owing to trouble with water or poor demand for ore.

In the area where the vein-like ore-body is predominant, south and east of the old escarpment, deep cross-cuts may prove reserves, as in one case where not only is an old vein being worked in depth but new ore-bodies have been discovered.

Brachiopod Nomenclature: The Genotype of *Spirifer*

By S. S. Buckman.

IN this Magazine, August, 1919, p. 371, Dr. J. Allan Thomson has an article on the above subject, in which he appears to be expressing the hope that *Spirifer cuspidatus* may not be taken as the genotype of *Spirifer*, though he thinks that certain rules of zoological nomenclature drive him to that conclusion.

It is all very well for zoologists to draw up rules with regard to nomenclature, but they can get tied up with them; and then fresh rules must be made to interpret the former, which may go on *ad infinitum*. Nowadays in science as in politics we are hung up with too many rules. Rules breed rules, and the worse they are the more they breed. So the fewer rules the better. But there is one rule necessary in nomenclature—read the original diagnosis and try to give effect to the author's intention, so as to fit it to modern requirements.

Why is *Sp. cuspidatus* to be the genotype of *Spirifer*? Because it is the first species mentioned. That may be denied, but if it were

[1] The course of this escarpment is shown in pl. iii of the memoir.

true the first species rule is itself an absurdity. It is just a contrivance to save a compiler's time, relieving him of the necessity of reading an original diagnosis to find out an author's meaning. When the first species has obtained its position, not for a zoological reason, but for an alphabetical, a geological, or a typographical reason, its selection as genotype may result in an absurdity—it may fail to fill the author's diagnosis.

It may be urged that *Sp. cuspidatus* is the monotype of *Spirifer*. That I challenge. I would argue that the description of *S. cuspidatus* is a separate act, not a part of Sowerby's generic diagnosis. That is complete in itself. Supposing that the description of *S. cuspidatus* had been written by another author, then *S. cuspidatus* would not be the genotype of *Spirifer*. Why should it be so because the description was written by Sowerby ?

The diagnosis of *Spirifer* (*Min. Conch.*, ii, Feb., 1816, p. 41) says, " The shells of this genus " ; that is plural, that rules out a monotype ; the genus is founded on several species which are genosyntypes. This is shown further : " I think this genus will comprehend nearly all the shells retained as *Terebratula* by Lamarck which have a triangular foramen . . . The several individuals in which I have discovered spiral appendages (he mentions Derbyshire, Irish, and Van Diemen's Land specimens) bear a considerable natural affinity to each other, from which circumstance we may venture to place many analogous species in this genus, although their interior has not been fully exposed." That is what he has done with *S. cuspidatus* ; he has placed it in *Spirifer* on sufferance; as an analogous species, for he expressly says (p. 43), " I have not discovered the spiral appendages [of *S. cuspidatus*]." That excludes it effectually as the genotype. He placed it in *Spirifer* by intuition; it had the triangular foramen. It was a case of typographical necessity. His material of *Spirifer* with the spirals discovered was held up by the Linnean Society ; but the plate of *S. cuspidatus* was ready. It could not be placed in *Terebratula* ; it was *Spirifer* by presumption if not by proof. Anyone who has had to draw up lists of species and assign them to new genera will have been confronted with the same difficulty and have committed a similar act.

In choosing a lectotype of *Spirifer* out of these species of Derbyshire, etc., shells, consideration should be given to Sowerby's further writings. First is his description of *S. cuspidatus*, saying, " Spiral appendages . . . may be seen in *Anomia trigonalis* of Martin." That is the first species mentioned. Then in 1818 was published Sowerby's paper in the Linnean Transactions, vol. xii, wherein he figures *Terebratula striata* showing spirals. But in his description of *S. trigonalis* (M.C. ii, pl. cclxiii, p. 117) he admits that he had " confounded it with *Anomia striata* of Martin . . . in the Linnean Transactions ". Evidently he had discovered this mistake after the reading of his paper to the Linnean (December, 1814) and before the publication of his description of *S. cuspidatus* (February, 1816),

but was unable to alter the name in the Linnean paper, for it would have involved too much explanation. Because, evidently, fig. 1, pl. xxviii, of the Linnean Trans. is a synthetograph—the details of the coils taken from an example of *Anomia trigonalis* (refigured M.C. ii, pl. cxxv, fig. 1) enlarged, revised, and adapted to an outline of *An. striata*; the large specimen of which he evidently used as the basis of his communication. This species he had from Derbyshire and Cork (M.C. ii, p. 125).

The genosyntypes, therefore, of Sowerby's *Spirifer* are really the *Terebratulæ* of Lamarck with triangular foramen, the *Anomitæ* figured and named by Martin, in which Sowerby had found spirals (M.C. ii, pp. 141, 142). These are *An. striata* and *An. trigonalis* which he had confounded with it—the Van Diemen's Land specimens may be ruled out. The authors who have chosen *An. striata* to be the genolectotype seem to be quite within their right. In that case, choice having been made, it stands good.

On the Distribution of *Productus humerosus* (= *sublaevis*) and the Zonal Range of the "Brachiopod Beds" of the Midlands.

By Professor T. Franklin Sibly, D.Sc., F.G.S., Armstrong College, Newcastle-upon-Tyne.

In 1908 the *Productus humerosus* beds in the Carboniferous Limestone of Caldon Low, N. Staffs, were tentatively assigned to the Lower *Dibunophyllum* zone, D_1, of Vaughan's classification. The slender evidence for this correlation was set out in my paper on the Midland Area.[1]

More recently the researches of Mr. L. M. Parsons in Leicestershire have established the *Dibunophyllum* age of the well-known *Productus humerosus* beds of Breedon-on-the-Hill and Breedon Cloud. Mr. Parsons showed that the dolomites with *Productus humerosus* in those localities contain *Cyrtina septosa*, a well-known D_1 shell; that they are overlain conformably by dolomites with chert which yield, at Breedon Cloud, a rich D_{2-3} fauna of corals and brachiopods; and, further, that they are underlain conformably, at Breedon-on-the-Hill, by beds with *Lithostrotion irregulare* and *Cyathophyllum* aff. *murchisoni*.[2] The position of the *Productus humerosus* beds of Leicestershire at the top of the subzone D_1 was thus firmly indicated, and the above-mentioned correlation of the beds at Caldon Low incidentally received confirmation.

In the interval it had become known, through the researches of Delépine and Vaughan, that *Productus sublævis* de Koninck, a species which includes *Pr. humerosus*, Sowerby, occurs persistently and abundantly on a much lower horizon in Belgium and in the

[1] Quart. Journ. Geol. Soc., vol. lxiv, 1908, p. 44.
[2] Ibid., vol. lxxiii, 1918, pp. 94–100.

Clitheroe district of Lancashire, namely, in the upper part of the *Caninia* zone (C_2).[1]

It is, therefore, evident that *Productus sublævis* occurs abundantly on two widely different levels in the Avonian, one in the Upper *Caninia* Zone, the other at the top of the Lower *Dibunophyllum* Zone. Dr. Wheelton Hind, in questioning Mr. Parsons's reference of the *humerosus* beds of Leicestershire to D_1, and at the same time affirming his own belief in a *Caninia* age for the *humerosus* beds of Caldon Low, failed to take this view.[2]

Strong confirmation of the *Dibunophyllum* age of the Caldon Low beds is now supplied by Mr. J. Wilfrid Jackson's discovery of *Productus humerosus* in limestones of "Brachiopod Bed" type in Dove Dale, only a few miles to the north-east of Caldon Low.[3]

The "Brachiopod Beds" of North Staffordshire and Derbyshire were described by me as an abnormal facies, and assigned to D_2, with the qualifying remark that they possibly encroach upon D_3.[4] They have long been accepted as "knoll-reef" deposits of D_2–D_3 age, paralleled by the upper or Cracoe knolls in the Clitheroe–Craven region of Lancashire, and by the massif of Visé, in Belgium. It is, however, most interesting to find in Mr. Jackson's account of the occurrence of *Productus humerosus* in Dove Dale, evidence which definitely suggests that the "Brachiopod Bed" phase in the Midlands ranges downwards into D_1. The limestones bearing *Pr. humerosus* in Dove Dale are clearly of "knoll reef" type, both in their faunal characteristics and in their lithic structure; and the top of D_1 is at once suggested as their horizon by a consideration of the *humerosus* beds of Leicestershire. It may be remarked that if the *humerosus* beds of Dove Dale lie some 500 feet below the top of the Carboniferous Limestone, as suggested in Mr. Jackson's account of them, then their stratigraphical position corresponds rather closely with that of the D_1–D_2 boundary as roughly determined in the Buxton-Longstone traverse of the Midland area.[5]

In concluding this note I take the opportunity of expressing the interest with which I am following Mr. J. W. Jackson's researches in the western part of the Midland area, a tract which was most inadequately studied by myself, and the hope that he will succeed

[1] "In the Franco-Belgian area the early, smooth form of *Pr. sublævis* occurs in a persistent band between Tournaisian and Viséan. In the South-Western Province this mutation is very rare; it has, however, been recorded from the C_2 oolite of Burrington. In the Clitheroe area, the early *Pr. sublævis* enters at the top of C_1 and forms a persistent band at the top of C_2 (as in Belgium)." (A. Vaughan, Quart. Journ. Geol. Soc., vol. lxxi, 1915–17, p. 47.)

[2] Geol. Mag., 1918, p. 480. Dr. Hind quoted the occurrence of *Cyrtina septosa* in the *humerosus* beds of Leicestershire as one indication of *Caninia* age as against D_1 age, notwithstanding the fact that *Cyrtina septosa* occurs in D_1 of Derbyshire and the South-Western Province, and characterizes a persistent band in D_1 of the North-Western Province.

[3] Geol. Mag., Vol. LVI, 1919, p. 335 and pp. 507–9.

[4] Quart. Journ. Geol. Soc., vol. lxiv, 1908, pp. 47–50.

[5] Ibid., vol. lxiv, 1908, p. 39, fig. 2.

in throwing further light upon the problem of the "Brachiopod Beds". Little or nothing is yet known regarding the transition from these "knoll-reef" deposits into the standard limestones of the district, while their rich fauna affords a great field for discriminating study.

The Pygidium of the Trilobite.

By Percy E. Raymond, Ph.D., Harvard University, Cambridge, Massachusetts, U.S.A.

ALTHOUGH the process of development of the pygidium in the trilobite has been known since the time of Barrande, its significance does not appear to have been appreciated, and much of the modern speculation on the classification of trilobites is based upon the erroneous idea that those species whose form is most annelidan are most primitive. As a matter of fact, the study of both morphology and ontogeny shows that in this group the large pygidium is primitive and the small one specialized.

The growing point in trilobites is, as in all other arthropods, immediately in front of the anal segment. This was proved by Beecher from a study of the appendages of *Triarthrus*, and is confirmed by facts more recently afforded by specimens of *Neolenus* and *Cryptolithus* having the appendages attached. New segments must, therefore, be introduced during moults, and each is pushed forward through the pygidium by those which are added later. While these segments are, as thus introduced, potentially free, they do not actually become so until they are pushed off from the anterior end of the pygidium. The thorax, therefore, grows through the degeneration of the pygidium. This process can be seen in the ontogeny of all species where any considerable number of growth-stages are known, but can be studied in greater detail in Barrande's classic descriptions of *Sao hirsuta* and *Dalmanites socialis*. In all cases it is found that the pygidium of the protaspis is proportionally larger than at any later stage in the life-history, and this is equally true of an elongate Mesonacid or of a Phacopid such as *Dalmanites*. If the proportional length of the pygidium of *Sao* at various stages be examined, it will be found that in the very smallest protaspis it is about 30 per cent of the whole, at a length of 1 mm., while there are still no free segments, the animal is practically isopygous, and from this stage to a length of 7 mm. the proportional length steadily drops to the 7 or 8 per cent which remains in the adult. All trilobites, whether the adult has a large or a small pygidium, show this same process, and Troedsson has recently described a particularly interesting case. The pygidium of *Dalmanites eucentrus* (Angelin), when 1·28 mm. long, has eight pairs of pleural ribs, indicating the possession at that stage of two more segments than the adult.[1] This case is of the more importance on account of the

[1] Lunds Univ. Årsskr., n.f. avd. 2, bd. 15, nr. 3, 1918, pp. 57–67, pl. i, fig. 23.

close relationship of *D. eucentrus* and *D. mucronatus*. The latter species appears first in the *Staurocephalus* beds, which are beneath the Brachiopod Shales containing *D. eucentrus*. The pygidium of the adult *D. mucronatus* is larger than that of the other species, having eight pairs of pleural lobes. In short, *D. eucentrus* seems to be descended from *D. mucronatus*, and in its youth passes through a stage in which it has a large pygidium like the latter.

All of this shows that the free segments of the thorax become such by the breaking down of a large pygidium, and that a small pygidium is the result of the degeneration of a large one. Further, that a large pygidium is not made up by the fusion of segments once free, and so is not a specialized organ in the sense that the metasomic shield of *Limulus* is.

If trilobites be examined with the assistance of these facts, rather than with the aid of the theory of origin from a numerously segmented annelid, much of the supposed specialization of Hypoparian trilobites disappears. The Agnostidæ, Eodiscidæ, Trinucleidæ, and the like are doubtless specialized—nothing which is not specialized can exist—but they are specialized simple trilobites. This is shown not only by the small number of free segments and relatively large pygidia, but by the absence of compound eyes and the presence of marginal or submarginal facial sutures, features in which they agree with the simplest type of protaspis.

The Pygidium in the Agnostidæ.

As to which shield is which in the Agnostidæ, I can only say that I have exhausted the collections accessible to me in searching for a specimen retaining the hypostoma. I have brought the case to the attention of Doctor Walcott and his assistants, and Mr. B. F. Howell, of Princeton University, is going to make a special search in the shale of the Middle Cambrian of South-Eastern Newfoundland this summer. I appeal to any student having specimens preserved in shale to make an attempt to find a specimen with the hypostoma in position. There are other possible lines of evidence, but none so satisfactory. Pending such evidence it may be pointed out that no other trilobite has a free plate on the ventral side of the pygidium, that Wahlenberg, Dalman, Brown, and Hisinger used an orientation the reverse of that now accepted, and that as now placed the tips of the pleuræ of the thoracic segments curve forward instead of backward as in other trilobites. If one take plate vi of Angelin's *Palæontologia Scandinavica* and reverse it, he will find that all of the figures appear more natural. In the accepted position the tips of the pleuræ of the thoracic segments and the pleural furrows point forward. In the reversed position they point backward, as in all other trilobites. In the accepted position every species has a tubercle on the median line of the pygidium. In the reversed position this would be on the cephalon, where it would more naturally occur. In the accepted position,

the "glabella" is less furrowed than the axial lobe of the "pygidium", a condition unusual among trilobites. In the reversed position, the axial lobe of the anterior shield usually shows three pairs of furrows, the normal number of glabellar furrows in most trilobites.

The only valid objection which I can see to reversing the usual orientation is that in the new position the segments would overlap in a direction opposite from that of all other Crustacea. That difficulty appears to be a serious and fundamental one.

The Protaspis.

Professor Swinnerton has introduced a new point of view, but one which might have been expected, by suggesting that the protaspis is a specialized larva, adapted to a planktonic mode of life, and that characteristics derived from its later development have no phyletic significance.[1] This is, of course, the view which has lately been held by nearly all zoologists concerning the nauplius of recent Crustacea, and both views have their origin in the "annelid" theory. Why, if trilobites were evolved directly from benthonic annelids, did they not retain the old planktonic trochophore, instead of evolving a new type, which in no way resembled the supposed ancestor or its larva?

Swinnerton says that the larvæ of the Mesonacidæ are the most primitive known. That may be true, as they are certainly the most ancient, but he continues to overlook the fact that the very youngest stage of the Mesonacid larva has not yet been found. Beecher pointed this out, and roughly figured a specimen younger than any illustrated by Ford or Walcott.[2] The eyes of this specimen were very nearly marginal, and in the youngest protaspis probably were actually on the edge. Beecher had worked over the Ford collection of larval Mesonacidæ, and certainly did not ignore them in making his classification. As a protaspis, the larva of the Mesonacidæ does not differ fundamentally from that of other trilobites, but the development is different, because of the absence of facial sutures.

Irrespective of the presence or absence of eyes, the circular or broadly oval form of the protaspis shows that beyond question it was a member of the plankton. But the evidence seems to indicate that it was not there as a secondarily adapted larva, but because its ancestors occupied that habitat. The broad lateral expansions (pleural lobes) present in larva and adult alike gave to the trilobites a shell which was easily kept afloat, and while not adapted to rapid swimming was a source of buoyancy. It has been shown above that the large pygidium is primary, that is, those trilobites are most primitive which are best adapted to keep afloat, and those most specialized which become adapted, by assuming a worm-like form, to crawling

[1] Geol. Mag., Vol. LVI, 1919, p. 109.
[2] *Amer. Geol.*, vol. xvi, 1895, p. 175, fig. 6.

life on the bottom. As had already been suggested, first, I believe, by Spencer, the pygidium was probably used as a caudal fin, perhaps more in the manner of the up and down motion of the tail of *Sagitta* than in the spasmodic flaps of a lobster. That the longitudinal muscles had considerable power, however, is shown by the great widening of the axial lobes of many trilobites with large pygidia. The appendages also show that most trilobites were swimmers as well as crawlers, though none so far investigated show any particular adaptation for the purpose of swimming except *Triarthrus*, whose pygidium is small.

The trilobite was not a powerful swimmer, but on the other hand it was not in any case entirely specialized for bottom life. The need for a floating type of larva was not great, since floating characteristics dominate over crawling characteristics in the adults, and thus such evidence as exists points to a pelagic rather than a benthonic ancestor for the group.

Backward Migration of the Eyes.

Beecher made no attempt to explain this migration, which formed so fundamental a feature in his classification. Two factors seem to be involved. In many cases there was little actual change of position, but the eyes of the adult are relatively further back because the brim in front of them has grown outward. In others there is actual backward translation, and this seems to be due to the increase in size of the anterior digestive portion of the alimentary canal, which bulges out the anterior end of the glabella, pushes back the mouth, and doubtless, the eyes, their nerves and ganglia. This enlargement of the "stomach" is probably correlated with the change from a planktonic mode of life, where the food was chiefly the concentrated micro-organisms, to the benthonic habitat, where an omnivorous or even vegetable diet may have been adopted. This change, though one of food, seems to have been so fundamental that its results became impressed upon the race, and thus the position of the eyes came to be of classificatory importance.

I think it will be evident from what has been said above that trilobites as unlike as *Cryptolithus*, *Harpes*, and *Dionide* could be descended from an *Agnostus*-like ancestor, and that those who wish to place the Agnostidæ and Trinucleidæ among the degenerate animals must bring forward some proof for their assertions which is not based upon the theory that trilobites descended from benthonic annelids. For further details and a full statement of the ideas expressed above, the reader is referred to a memoir by the author that is shortly to be published by the Connecticut Academy of Arts and Sciences.

The Ammonite Siphuncle.

By A. E. Trueman, D.Sc., F.G.S., University College, Cardiff.

IT is well known that the chambers of Cephalopod shells are connected by an organ called the siphuncle, which passes through the septa by the septal necks. Many investigators who have studied these shells have made careful observations on the siphuncle, hoping thereby to throw light on its functions. Such workers as Branco, Blake, Zittel, and Owen, among many others, have written on this problem, while more recently an elaborate study of the structure and constitution of the siphuncle has been made by Grandjean,[1] who gives a detailed account of the organs associated with it. Among the many points established by Grandjean's work, not the least interesting is the fact that the siphuncular tube of Ammonites and Belemnites is composed of calcium phosphate, and not, as had previously been stated, of calcium carbonate.[2] But in spite of Grandjean's careful examination of the less obvious characters of the siphuncle, it appears that certain facts, much more easily observed, have hitherto been overlooked.

Terms.

The word "siphuncle" in Ammonite literature is used somewhat loosely, just as the word "siphon" is used in the same connexion by French authors. As Grandjean pointed out, however, the "siphon" (or siphuncle) proper is a membranous organ; the tube of calcium phosphate found in fossils, and commonly referred to as the siphuncle, is simply the solid sheath, which it will be more convenient for the present purpose to call the siphuncular tube or envelope.

Continuity of the Siphuncular Tube.

When examining some large sections of Ammonites the writer noticed that the siphuncular tube was not continuous through all the chambers to the body-chamber, even when the sections were perfectly median. It was at first thought that this was an unusual character, but when other sections were examined similar facts were noticed, and a more systematic inquiry was therefore undertaken. Ammonites were examined by kind permission in the College and Museum collections at Bristol, Cardiff, and Nottingham, and while only a small proportion of the ammonites seen were sufficiently complete or accurately cut to give the desired information, in every specimen which showed enough detail the same rule was found to hold good.

A section of *Asteroceras obtusum* (Sow.), of diameter 70mm. in the

[1] F. Grandjean "Le Siphon des Ammonites et des Belemnites": Bull. Soc. Géol., France, ser. IV, vol. x, 1910, p. 496.

[2] This further point of resemblance between Ammonites and Belemnites is interesting in view of Dr. W. D. Lang's recent suggestion concerning their classification (Proc. Geol. Assoc., vol. xxx, p. 59).

Natural History Museum, Nottingham, shown diagrammatically in Fig. 1, will serve to illustrate the character in question. That the section is cut accurately along the median plane is shown by the position of the keel and the size of the septal necks for the passage of the siphuncle. The siphuncular tube can be clearly seen along the greater part of the spiral, but after a diameter of 38 mm. (S, Fig. 1) no trace of the siphuncular tube can be made out in the succeeding ten chambers. The wide septal necks in the section at that point show that its non-appearance is not due to asymmetry.[1] Apparently the only conclusion that can be drawn, therefore, is that the siphuncle, which was, of course, continuous throughout the spiral, had an envelope which did not extend through the ten chambers preceding the living chamber.

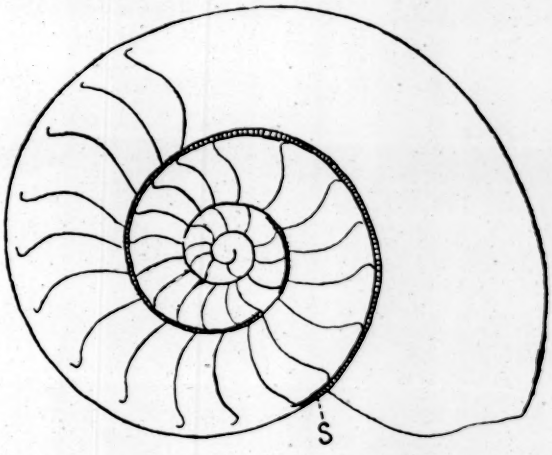

FIG. 1.—Diagram of a section of *Asteroceras obtusum* (Sow.) showing the siphuncular envelope (S).

Similar facts were also observed in the following Ammonites :—

1. A large unidentified specimen from the Inferior Oolite in University College, Cardiff. Diameter 330 mm. Part of living chamber present. Six chambers without a siphuncular envelope. These six chambers and the living chamber are filled with oolite, the earlier chambers with calcite.

2. *Parkinsonia* sp. University College, Nottingham. A specimen, diameter 240 mm., septate throughout (that is, with no part of the body-chamber retained), has no siphuncular tube in the last three-quarters of a whorl. That is, for at least fifteen chambers there was no siphuncular envelope.

3. *Deroceras* sp. Natural History Museum, Nottingham. Diameter 85 mm. Septate throughout. No siphuncular tube after diameter 44 mm., that is, at least fifteen chambers without.

4. *Harpoceras exaratum*. University College, Cardiff. Diameter 76 mm.

[1] Further, asymmetry is of extremely rare occurrence in such keeled ammonites. See Swinnerton & Trueman, Quart. Journ. Geol. Soc., vol. lxxiii, 1918, p. 54.

Portion of living chamber present. No siphuncular envelope after 43 mm., that is. twelve chambers without.

5. *Oxynoticeras oxynotum.* Welsh National Museum. Has no siphuncular tube for twenty-five chambers, the whole of the last whorl.

6. ? *Lioceras* sp. Bristol University. Diameter about 150 mm. Body-chamber present. No siphuncular tube in last nine chambers. The body-chamber and the preceding nine chambers have oolite filling, the earlier chambers have calcite.

It frequently happens that while the chambers of an Ammonite are filled with calcite or other crystals, the body-chamber is filled with material such as clay or oolite, which was able to get in when the animal decayed. But in several of the Ammonites referred to above, not only the body-chamber, but also the chambers without a siphuncular tube, were filled with such material, probably indicating that when the Ammonite died the siphuncle decayed, allowing detrital material to enter those chambers where there was no siphuncular tube. Using this type of evidence it would be possible to extend the above list very considerably.

Other Indications of a discontinuous Siphuncular Tube.

While the most obvious way of investigating the continuity of the siphuncular tube is by means of median sections, yet useful information concerning some Ammonites has been obtained from casts and impressions. These cases may be considered in three groups :—

1. In some casts of Ammonites, especially those which have been rubbed or polished, the siphuncular tube may be seen along the external margin. In such casts it was found that the siphuncular tube did not continue unbroken to the body-chamber.

For instance, a polished cast of an unidentifiable Ammonite in the teaching collection at University College, Cardiff, has a continuous siphuncular tube up to a diameter of 175 mm. Following this are three chambers, the remainder of the shell not being present. The siphuncular envelope in these chambers is discontinuous (see Fig. 2). In the last two chambers short portions of the tube (S 2, S 3) are attached to the front septal neck only ; in the third chamber the portion of the tube is free (S 1) and on the side of the cast. It appears, therefore, that the tube was discontinuous in these chambers (and in any others in front that may originally have been present), and that the secretion of the solid tube commenced between the septa, each portion becoming attached to the septal neck in front. With the death of the animal the siphuncle decayed, and these portions of the tube were unsupported, and the shell having fallen on its side they either hung loosely from their attached ends (S 2, S 3) or slipped along the inside of the shell (S 1).

A similar condition is shown by an example of *Hoplites deshayesi* (Leym.) in the Welsh National Museum. In this specimen part of the living chamber is present at a diameter of 70 mm. The siphuncular tube appears on the outside of the cast as a continuous black

band, passing through all but the last two chambers. In the last chamber no trace of any siphuncular tube can be seen, but in the preceding one a short portion of the tube has slipped along the side exactly as in Fig. 2 (S 1).

These two cases suggest that in some of the sections described the apparent absence of any siphuncular tube may be similarly due to the falling away of the inter-septal portions of the tube. Nevertheless, there is no doubt that the tube was not present in the last few chambers of all the specimens mentioned.

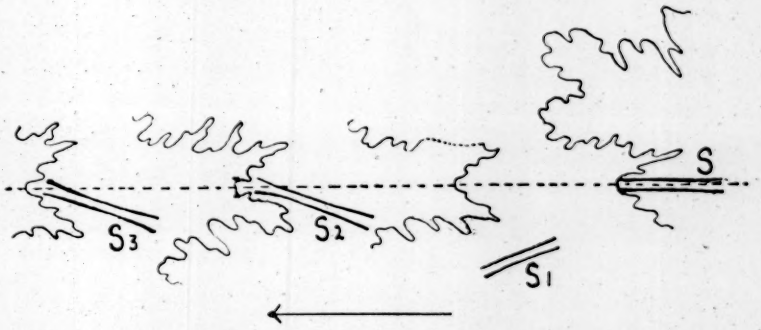

FIG. 2.—Diagram showing the discontinuous siphuncular tube in a Hildoceratid Ammonite. S represents part of the normal siphuncular tube, with loose portions at S_1, S_2, and S_3.

2. Casts of *Aetomoceras scipionianum* (d'Orb.) and allied forms found in the phosphatic beds at Radstock, Somerset, afford further confirmation. The siphuncular tube is generally broken away, leaving a groove along the external margin, but the keel is still present on the cast of the body-chamber and on several chambers preceding it. This suggests that there was no siphuncular tube in those chambers, otherwise it would also have been broken away.

3. Many specimens of *Psiloceras* cf. *planorbe* (Sow.), found in the Lias at Lavernock, near Cardiff, have been flattened in preservation, and in many cases the shell was evidently so thin that it is only now represented by the outer horny layer. This is soon worn or even blown away, and then the impression often shows the siphuncular tube as a white band running round the spiral.[1] As this does not extend into the outer two whorls it is extremely probable that here again there was no siphuncular tube in the last few chambers.

THE SIPHUNCULAR TUBE IN YOUNG AMMONITES.

There are two possible explanations of this absence or incompleteness of the siphuncular envelope in the last few chambers

[1] Mr. F. F. Miskin, F.G.S., kindly examined a number of these Ammonites, and proved that this white material was calcium phosphate, and therefore represents the siphuncular tube.

of Ammonites. It may have been an old-age or adult character, indicating feebleness of powers of phosphate secretion, or it may have been a normal feature of growth, the envelope being formed by a siphuncle but always leaving several chambers in which it was incomplete.

To test the truth of this latter suggestion sections were cut through a number of young Ammonites, those selected being young individuals with at least a portion of the body-chamber preserved, and not simply the inner whorls of adults. In each example investigated it was found that in the chambers preceding the living chamber there was no siphuncular envelope.

The following specimens were cut :—

Hildoceras cf. *bifrons* (Brug.), from Grantham. Diameter 24 mm. Scarcely any sign of a siphuncular envelope in the last whorl.

Dactylioceras sp. from Grantham. Diameter 3·5 mm. No siphuncular tube in last two chambers.

Amblycoceras sp. from Leckhampton. Diameter 4·2 mm. No siphuncular tube in last three chambers.

It therefore appears that in many, if not all, ammonites, young and old, the siphuncle is without an envelope in the chambers preceding the body-chamber. The number of chambers in which there is no envelope apparently increases with the age of the individual, but probably depends on other conditions also.

Previous Observations on the Extent of the Siphuncular Tube.

So far as the writer is aware, this incompleteness of the siphuncular envelope has not previously been recorded, although, curiously enough, Zittel has described an exactly opposite instance.[1] In some casts of *A. elimatus* from Williamswitz the siphuncular tube is not preserved, and the groove which presumably marks its position appears to persist a short way into the body-chamber. Beyond this Zittel gives no information, and apparently did not refer to it further in his later works. While this observation may indicate that in some species or individuals the secretion of an envelope proceeded more quickly than in those described above, it is doubtful whether the secretion actually occurred within the body-chambers, and it must be pointed out that Zittel was relying for his evidence not on the actual siphuncular envelope but on the extent of a groove which may have contained it.

Grandjean suggested that Zittel's observation affords a possible explanation of the formation of the siphonal membranes, the association of which with the covered siphuncle he was unable to understand.[2] It may be briefly noted that the facts recorded above make it possible to give an equally simple explanation.

[1] In Oppel, Palæont. Mitt. Mus. d. k. bayer. Staates, Bd. ii, 1868, pp. 79–80. I have to thank Mr. F. T. Ingham, B.Sc., for supplying particulars of this paper.

[2] Op. cit., p. 502.

Function of the Siphuncle.

It is not the writer's intention to enter into any lengthy speculation concerning the use of the siphuncle either among Ammonites or nautiloids. Many writers have dealt with the question, and nearly every one has a different explanation to offer. A summary of a number of these suggestions is given by Blake,[1] and many others have been briefly discussed by Zittel.[2] It will, however, be interesting to re-examine several of these theories in the light of the observations recorded.

The early conception of the Ammonite shell was as an apparatus by which the animal could float on the surface of the sea, or by diminishing the amount of gas in the chambers could sink to the bottom. Various writers suggested ways in which this might have been accomplished, some imagining a siphuncle which was capable of expanding and so expelling the gas, others suggesting that the siphuncle introduced fluid into the chambers and so achieved the same result.[3] Both these suggestions were deemed by most writers to be inadmissible when it was found that the siphuncle was surrounded by a solid envelope. But if, as we have noticed, in the last few chambers the siphuncle had no envelope, this objection no longer holds, for a very small change in density would suffice to lower or to raise the shell, and this could be made by altering the contents of the last few chambers only.[4] Nevertheless, the author would not for a moment suggest that the siphuncle performed any such function.

In a recent paper Mr. L. F. Spath has put forward another suggestion concerning the use of the siphuncle in *Nautilus*.[5] He considers that this strong central siphuncle of *Nautilus* helps to prevent the animal from falling away from its shell when it moves forward to form a fresh septum. Apparently this suggestion is based on the somewhat amusing but scarcely scientific account of the capture of a specimen of *Nautilus pompilius* written by a lady and quoted by E. A. Smith.[6] According to this story the animal breaking its siphuncle fell from its shell and *showed no desire to re-enter it*! Against this may be given the experience of Dr. Willey, who made saw-cuts in the shells of *Nautilus* and cut the siphuncles just behind the body, yet the animals lived on, and apparently showed no tendency to fall from their shells.[7] It is fairly certain, therefore,

[1] J. F. Blake, *British Fossil Cephalopods*, vol. i, 1882, p. 39.

[2] K. v. Zittel, *Handbuch der Palæont.*, Bd. ii, pt. i, p. 348.

[3] T. Wright, *Monograph of Lias Ammonites*, Palæont. Soc., 1878–86, p. 174.

[4] The total weight of the ammonite animal and its gas-filled shell was probably not very different from the weight of water it displaced. See Dr. F. Willey, *The Pearly Nautilus*, 1902, p. 747.

[5] L. F. Spath, "Notes on Ammonites": Geol. Mag., Vol. LVI, 1919, p. 30.

[6] E. A. Smith, "Note on the Pearly Nautilus": Journ. Conch., October 1887.

[7] Op. cit., p. 760.

that the siphuncle in *Nautilus* can hardly serve for such a purpose as Mr. Spath suggests. The animal would fit sufficiently tightly in the shell to prevent its falling out, even when the shell muscles were detached.[1] For instance, some force is needed to pull a dead gastropod, such as a snail, from its shell even after the muscle attachment is broken.

Without discussing at any greater length the functions of the Ammonite siphuncle it may be mentioned that in the writer's opinion the suggestions of Foord[2] and Dr. Henry Woodward[3] are much more reasonable than those mentioned above. These writers suggest that the siphuncle was of more importance in the young animal, perhaps then serving for attachment, but that later on this function was performed by the shell muscles. It is not unlikely also that the siphuncle was of much greater importance in the early stages of Cephalopod evolution than it is in Mesozoic and recent forms. This will be more clearly recognized when an attempt is made to assign a function to the siphuncle of a Belemnite, where it is almost certainly nothing more than the remains of an organ which was probably of value in the early history of the race, and perhaps in the early development of the individual. The tendency for the secretion of the siphuncular envelope in Ammonites to lag behind shell-growth suggests that the value of the siphuncle may at least have been declining.

Angra Pequena (Lüderitzbucht) and Subaerial Denudation.

By R. F. Rand, M.D.

IN recent years the name of Angra Pequena, conferred by Bartholomew Diaz, has been somewhat obscured by the designation Lüderitzbucht, the name given to this port during the German occupation. The latter name still holds, although a compromise, whereby the geographical area should retain the old name and the town be known as Lüderitz, seems desirable.

Angra Pequena (Lüderitzbucht) and Walfisch Bay are the only two useful harbours of the South-West African Protectorate. Apart from its harbour, the town of Lüderitzbucht and the surrounding district have received much attention owing to the considerable finds of diamonds which have been made along the coast, both to the north and to the south of the port.

To the geologist the Angra Pequena area is of interest as affording

[1] This would be equally true of Ammonites, in which Mr. Spath suggests that the complex lobes and saddles served as an attachment. See also Dr. W. D. Lang, "The Evolution of Ammonites": Proc. Geol. Assoc., vol. xxx, 1919, p. 63.

[2] H. O. Foord, *Catalogue of Fossil Cephalopods in Brit. Mus.*, vol. i, 1888, pp. 10–11.

[3] H. Woodward, *Pop. Sci. Review*, vol. xi, 1872, p. 113.

an admirable instance of æolian denudation. It is a desert area, a region of rock and sand. The average annual rainfall is 0·78 in. There are no running streams. Water for drinking purposes must be imported or distilled from sea-water.

The rocks are of the ancient metamorphic complex, so widespread over the Protectorate. A confused medley of granite, aplite, gneiss, and schists. There is much commingling of types as a result of injection, pressure, and earth-movement.

Overlooking the town of Lüderitzbucht there is a rocky eminence, known locally as the Diamantberg, which within an area of a square mile or so shows many types. The prevailing one is, perhaps, a biotite-schist, which in many places has been invaded to a varying degree by granite or by aplite. The difference in colour between the schistose and the granitic elements shows up the degree of admixture very clearly. In some places masses of schist are to be seen uninvaded by granite, in others masses of granite or of aplite occur without trace of schist. Here and there are large segregations of quartz. Veins and eyes of felspar are common. The rocks are exposed upon every side, for there is no vegetation that counts to mask or protect them.

Although the rainfall is so small the country is carved into hill and valley, and ravines course down the steeper slopes. The floors of the valleys are occupied by mixed sand and grit, a fluent medium, which is disposed much as water would be in a non-desert area, broadening as the valley opens out, narrowing as it closes in like a sand river-bed, which frequently provides the most convenient highway for man and beast. Heat by day and cold by night have their due effect no doubt, but it is the wind which is mainly responsible for the large quantities of rock-waste and debris which litter the surface upon all sides, and for the honeycombing the rocks have so frequently undergone.

The great destructive wind of this area blows from the S.S.W. It is a seasonal wind blowing from October until April. Years ago Andersson noted its effects upon the habits of certain birds. Perhaps only a light breeze in the morning, it rises to a gale in the afternoon, dying down again after nightfall. From time to time there are calm days. It is a wind laden with salt and with moisture where it first strikes the land; thereafter it lays the desert under tribute, and armed with grit and sand scours everything in its path.

No rock entirely withstands the attack. Effects vary. It is rather curious to see how in large boulders, say, of granite, apparently of even texture throughout, one portion of the mass may be merely dull polished and lightly scooped out, whilst another portion is deeply bitten into.

The biotite-schist shows the ravages conspicuously. The rock is pitted, riddled, and holed, with "worm-eaten", honeycombed effect. It rots away. Near to the sea, no doubt, the salt in the air, owing to its chemical reaction with the ferruginous element of the schist, adds to the destructive effect.

The holes bored into the rock are usually more or less circular in outline at the inlet, and burrow into the rock to varying depths. The cavities worn are chambered out and frequently coalesce, giving rise to cells and caves which are sometimes large enough to shelter man.

Should granite and schist have been rolled out into even, alternate laminæ, and the constituent minerals disposed in order, the holes may be regular in size and lie in a straight line. If equidistant, as they sometimes are, they may look as though drilled by human hand. Sometimes the outlines are quadrangular, and the rows may even suggest the pigeonholes in an office desk. There may be simply smoothing and dull-polishing of such a rock, and should the layers crop out vertically they show ridge and furrow, the harder granite being in relief.

Where there has been intimate admixture of felspar and schist the more resistant felspar stands out in studs. The veins of felspar also project, but with their sides unsupported the felspar is at the mercy of its main cleavages and falls in fragments. High up upon cliff-faces one may see holes which resemble those made by martins in some hospitable sandbank.

The granite varies very much in its resistance. Sometimes it is deeply holed and cavernous; sometimes it shells away in concentric flakes; sometimes it shows good resistance and is merely dull-polished.

The segregations of quartz are, as one would suppose, very resistant. Such masses have their surfaces more or less polished and lightly scooped out into shallow depressions of varying size. All salient angles are rounded off. There is a general smoothing over. Pitting, in quartz, when it occurs, is usually small and due to the breaking down of small less-resistant inclusions. Yet the foot of a quartz slope is littered with angular fragments, owing, apparently, to the minute fissures and joints which traverse the mass.

Most of the holes one sees, whatever the nature or texture of the rock, are driven more or less horizontally inwards, after the fashion of adits, but holes are sunk downwards also. The chemical action of the wind-borne salt and moisture, and the grind of the air-driven sand and grit, sap at all vulnerable surfaces. As the holes deepen they come more and more under the swirling effect and scour of the rock-fragments, sand, and grit which they come to harbour. They may be regarded as æolian "pot-holes".

The lofty sides of the ravines and gullies have their rocks deeply honeycombed and wind-bitten. Air-currents frequently course up or down them with violence. The holes may face up or down the ravine. Perhaps there are more which face downwards. Air-currents in broken country are so capricious and so easily deflected that there can be little rule.

One has to see the large quantities of waste littering the surface

to realize the rapid rate at which the rock is being destroyed, and one has to experience the force of the wind adequately to estimate its driving power from its set quarter.

No one doubts that the strong S.S.W. wind has been the agent by which a natural concentration of the diamonds in the valleys of the Lüderitzbucht district has been brought about, a concentration which has made their exploitation economically possible. As the diamonds have not been shown to extend very far inland it has been thought by some that marine agency has had something to do with their occurrence. It has been pointed out that the coast is undergoing slow upheaval, and that diamonds have been found in the material of the "raised beaches" which terrace the hills in certain of the valleys of the littoral. But as to this there seems to be no reason why the enrichment should not have taken place from a landward area, and not necessarily from seawards.

It is quite likely that the S.S.W. wind may be entirely responsible for the denudation of the parent diamond-bearing rock as well as for the concentration of the diamonds after being set free. The occurrence of the diamonds near to the sea is probably due to the fact of the denuding agent being a coastal wind. This coastal wind occupies a stratum which does not reach to any considerable height into the atmosphere. As one proceeds inland the country rises fairly rapidly. In the experience of the writer it may be blowing a gale at Lüderitzbucht, while at Haalenberg, 33 miles inland by rail, and considerably less as the crow flies, the air may be nearly still. Haalenberg is 1,816 feet above sea-level. An arborescent aloe, *Aloe dichotoma*, common in the interior, comes down to about this neighbourhood. It does not reach the coast, it could not withstand the wind, although there are switch forms of vegetation which can bow before the wind, and lowly plants, mostly of fleshy habit, which can win their way as far down as the sea. It would seem that we have in noting the habitat of such arborescent forms as *Aloe dichotoma* a guide to the limitations of the coastal wind in both vertical and lateral planes, and consequently to the area the denudation of which has furnished the diamonds.

The hills lying inland between Lüderitzbucht and Kolmanskop are of metamorphic rock, and in general resemble the Diamantberg. They are not high, and one hill is very much like another. Very curiously the broad effect of the landscape in this region is suggestive of a terrain which has been swept by an ice-sheet. There are the generally rounded outlines, the hummocky effects. The resemblance must be illusory, for subaerial denudation is going on so rapidly that one judges the outlines to have been comparatively recently imposed. The directional trend of the sand-blast may be responsible for the likeness.

REVIEWS.

SUMMARY OF PROGRESS OF THE GEOLOGICAL SURVEY OF GREAT BRITAIN FOR 1918. pp. 70, with 3 text-figures. 1919. Price 2*s.* 6*d.* net.

THIS publication forms remarkably interesting reading, for several reasons. In the first place we have at any rate a partial lifting of the veil of secrecy that has shrouded some of the more important work of the Survey during the War, and it is possible to make a shrewd guess at the nature of some of the more recondite investigations undertaken by its officers for the Navy, the Army, and the Air Forces. Besides references to the more obvious but exceedingly necessary advisory work on water supply and road-metal at home and abroad and the geology of mining and tunnelling on the Western Front, we are treated to the briefest cataloguing of such tantalizing items as "Reports on Selection of Quartz-crystals for Anti-Submarine Division of the Admiralty", "Report on use of Hexahedric Crystals of Iron-pyrites by the Germans", "Report on a Prize Cargo", and others of a similarly mysterious nature.

As is natural the activities of the small staff that remained were almost entirely diverted to work of an economic nature, or closely connected with the military and commercial necessities of the country. Under this category come reports on the oil-shales of Scotland, possible potash-bearing rocks from North Wales, copper, arsenic, salt, and cannel coal, with a rather full description of the occurrences of the latter in Scotland. There is also an interesting account of the lead and zinc mines in Scotland, including those of Leadhills and Wanlockhead, Newton Stewart, Tyndrum, and Strontian. A deposit of bauxitic fireclay in Ayrshire has been found to possess high value as a refractory.

In the way of pure geology the mapping of parts of Banffshire and Aberdeenshire has been revised and a good summary of this work is given. Part of this, by Mr. H. H. Read, has already appeared in the GEOLOGICAL MAGAZINE under the attractive title of "The Two Magmas of Strathbogie".

Seven valuable appendices are added to the report, all dealing with boreholes in different parts of the country, namely, Kent, Lincolnshire, Gloucestershire, Yorkshire, Holywell (Flint), and a place called Gosmore, which from a previous publication appears to be near Hitchin, although this is not here stated.

It is highly satisfactory to find that the issue of the extraordinarily valuable series of special reports on the mineral resources of Great Britain is still actively proceeding, three further volumes on iron-ores having just been issued, and that it is intended to keep the series up to date by the frequent issue of new editions. These publications have evidently filled a gap in the literature of economic geology in

this country. The forthcoming volumes will be awaited with much interest, and we may be allowed to hope that a volume or volumes on lead and zinc are now on the way.

R. H. R.

Special Reports on the Mineral Resources of Great Britain, Vol. VIII. Iron Ores; Hæmatites of West Cumberland, Lancashire, and the Lake District. By Bernard Smith, M.A. Mem. Geol. Surv. pp. 182, with four plates and 29 text-figures. 1919. Price 9*s*. net.

ALL geologists who are in any way interested in economic questions in general and in iron-ores in particular will rejoice at having at length an authoritative and complete account of the hæmatite deposits of north-western England. This is a subject of very great geological and technical importance, as to which reliable information has been singularly lacking, especially as regards later developments. Mr. J. D. Kendall's work on the subject was published over twenty years ago, and since then very little seems to have appeared in connexion with the geological aspects of this great industry.

The Geological Survey is to be congratulated on having found in Mr. Bernard Smith an author who is capable of dealing effectively with all sides of a large and complicated subject. He gives an interesting sketch of the early history of the iron-mines, beginning with the impetus given to commercial enterprise by the foundation of the great abbeys in the twelfth century and gradually leading up to the industrial revolution of 100 years ago, when blast furnaces using coal and coke replaced the primitive bloomeries of the Middle Ages, and eventually led to the establishment of such gigantic enterprises as the Barrow Hæmatite Steel Company, Limited, and the Hodbarrow Mine, with its output of 400,000 tons of ore per annum.

It is, of course, well known that the great importance of this hæmatite ore lies in its remarkably small proportion of phosphorus, which causes it to be eminently adapted to the manufacture of steel by the acid Bessemer process, and so long as the supply lasts the demand for this high-grade ore will inevitably continue. Fortunately there is every reason to believe that great reserves still remain untouched under the Duddon Sands and elsewhere. By the very nature of the case, such irregularly shaped and sporadic masses as these must be difficult to locate, the only means available being actual boring or sinking; purely geological reasoning is not of much avail, though a detailed study of the stratigraphy such as is here given is of much practical value in pointing out likely localities for such experiments.

Geologists will read with much interest Mr. Bernard Smith's lucid exposition of the facts and arguments which have led him to

the conclusion that the solutions giving rise to the metasomatic replacement of the Carboniferous Limestone travelled in the main downwards from the overlying New Red rocks; the first stage appears to have been the replacement of the tests of calcareous micro-organisms by compounds of iron, this change afterwards spreading to the fine-grained matrix and being accompanied or followed by a certain amount of silicification. The close connexion existing between ore-bodies and fault-fissures appears to be conclusive evidence of the truth of this explanation. Even the lode-like masses of hæmatite in the Skiddaw Slates and other ancient rocks seem to have been formed by descending solutions. The "sops" of Furness, which are obviously ancient pot-holes, were first filled by calcareous breccia and afterwards metasomatized by iron solutions, and there is no real support for the view that any ore-bodies were deposited in cavernous open spaces in the limestone.

The possible further underground extensions of the ore-field and the amount of probable reserves are fully discussed, and 120 pages are occupied by detailed descriptions of the mines, illustrated by excellent diagrams of the forms of the ore-bodies and their relations to varying rock-structures. It is estimated that the ore proved to exist amounts to about forty-five million tons, while probable reserves unproved, may be ninety million tons, most of this being in Cumberland. The Lancashire field seems to be rapidly approaching exhaustion, only five million tons of ore being actually known to exist.

This memoir is an admirable example of the judicious combination of scientific deduction and practical knowledge that is so highly desirable in the literature of economic geology. R. H. R.

Special Reports on the Mineral Resources of Great Britain. Vol. IX, Iron Ores (cont.): Sundry Unbedded Ores of Durham, East Cumberland, North Wales, Derbyshire, the Isle of Man, Bristol District, and Somerset, Devon, and Cornwall. By T. C. Cantrill, R. L. Sherlock, and H. Dewey. Mem. Geol. Surv. pp. 87, with 7 figs. 1919. Price 3*s*. 6*d*. net.

In this volume we have a useful collected account of some relatively unimportant sources of unbedded ores, partly in the form of replacement deposits and partly as true mineral veins. Some of the occurrences, as those of the Carboniferous Limestone of North Wales, Derbyshire, North Somerset, and Devon, are similar in form and origin to the great hæmatite deposits of North-Western England. In the Isle of Man and in the Coal-measures of Bristol hæmatite occurs in veins, perhaps due to alteration of calcite and dolomite by ferruginous waters from the Trias. The spathic vein-ore of West Somerset, Devon, and Cornwall consists in depth of chalybite, converted near the surface to limonite. In some places spathic ore is

associated with fluorspar and galena, and is probably due to heated vapours and solutions derived from igneous magmas.

It is shown that the total reserves in the localities described are insignificant, amounting to perhaps 750,000 tons, as compared with a possible 135 million tons in Cumberland and Lancashire; nevertheless, some of these ores are of good quality, and may eventually become valuable for special purposes. It may be mentioned that the hæmatites of the Forest of Dean and South Wales, which are on a much larger scale, are described in a separate volume.

Special Reports on the Mineral Resources of Great Britain. Vol. X, Iron Ores (cont.): The Hæmatites of the Forest of Dean and South Wales. By T. Franklin Sibly, D.Sc. Mem. Geol. Surv. pp. 92, with 14 figs. 1919. Price 4*s.* net.

If direct evidence were required of the value to industry of the Geological Survey, none could be more convincing than the series of Special Reports on the Mineral Resources of Great Britain which have been produced during the War. They will appeal to a different and perhaps more practical public than do the Geological Memoirs; but on the other hand it is clear that the high standard of these practical reports could not have been attained without the purely geological researches previously made by the Survey. The present monograph is a welcome addition to the literature of iron-ores. Dr. Sibly describes the features of the hæmatite deposits in the Carboniferous Limestone briefly and lucidly. The explanation of the origin of the hæmatite bodies should be of interest to students of economic geology, as the theory of the metasomatic replacement of the limestone by iron-ore from ferruginous solutions derived from the Trias is satisfying and provides a good example for instructional purposes. If there is any genetic connexion between the ore bodies and the other metasomatic replacement of the limestone by dolomite it is obscure and left unsettled, though there is evidence that dolomite was formed at three periods, so that it is necessary to distinguish between primary dolomite and contemporaneous and subsequent dolomitization. The greater portion of the report deals with accounts of the mines, both working and abandoned. Statistics of output in the past and also estimates of the amount of iron-ore remaining (so-called "reserves") are given, though the author sees no hope for the resuscitation of the mines under present conditions.

Recent Geophysical Reprints.

1. An Apparatus for growing Crystals under Controlled Conditions. J. C. Hostetter. Journ. Wash. Acad. Sci., vol. ix, 1919, p. 85.
2. The Hydrated Ferric Oxides. E. Posnjak and H. E. Merwin. Am. Journ. Sci., vol. xlvii, 1919, p. 311.

AS is well known the Geophysical Laboratory of the Carnegie Institute put aside its usual scientific pursuits to help win the War, and on this account only two of the latest issue of reprints from the Laboratory are sufficiently geological to call for notice in these pages.

1. The apparatus for growing crystals described by Hostetter has its origin in a German patent of Krügen & Finke. Its principle is the circulation of solution from a saturator to a crystallizer and back again. The temperature difference varied with the salt used and was generally kept well under 0·5° C. The description is clear, and is illustrated by an admirable diagram.

2. The hydrated ferric oxides, though a difficult subject, have attracted considerable attention in the past. Many of the individual results attained by Posnjak & Merwin are of the nature of confirmation rather than of original discovery, but this does not detract from their importance. Our knowledge in its *toute ensemble* was hopelessly confused, and the present contribution is most welcome. Its main features may be summarized as follows :—

Ferric hydrates, both natural and artificial, fall into two great classes : Class I, orange to orange-yellow ; and class II, red to reddish-brown. Class I has the empirical formula $Fe_2O_3.H_2O$, with variable adsorbed and capillary water. Class II is of a different constitution.

Only the natural products have been met with as definite crystals. These are of three kinds : Class I, Goethite and Lepidocrocite ; Class II, Turgite.

Limonite falls to Class I. Much of what is commonly called limonite is shown to be fibrous goethite, but other samples are indecipherably "amorphous", and for these the name limonite is retained. Limonite in this restricted sense may or may not be goethite. Its density and refractive index, when corrected for the effect of adsorbed and capillary water, point in the direction of the goethite correlation, but as yet the evidence is not considered conclusive. Might not the absorption spectrum of the streak help to fill in this gap in our knowledge ?

Turgite is interpreted as a solid solution of hæmatite and goethite, but in this direction the authors have not developed their case very clearly. They base upon the density of the three minerals, and then remark "all other evidence at hand is in favour of this assumption". But in relation to the dehydration behaviour of turgite, we had previously been told "the shape of the curve

plainly signifies that the water in turgite is held in a different way from that in the other hydrated oxides ", and later, " no sudden decomposition takes place anywhere, and it would seem that turgite unlike the other hydrated ferric oxides, is not a definitely hydrated compound." How are these statements to be reconciled with the view that some turgites contain about 50 per cent of goethite ?

Of many other points of interest the following may be chosen :—

(*a*) The orange to orange-yellow hydrates (Class I) are found to begin to decompose at an appreciable rate at about 200° C., while at about 300° C. their decomposition becomes labile.

(*b*) For the same class, dehydration is irreversible where combined water is concerned, and approximately reversible where uncombined water is concerned.

(*c*) For turgite (Class II) dehydration is irreversible, but no temperatures comparable with those referred to in (*a*) have been detected.

In conclusion one may perhaps venture on a complaint. Much might have been gained by clearer exposition. It will suffice to mention a couple of instances of unnecessary obscurity in regard to figure 2 with its fourteen independent graphs. Each graph is numbered, and the reader is referred to two tables elsewhere in the paper to find, by help of these numbers, under what names the fourteen specimens experimented with were received from various museums. It is a matter of further research to realize how far this naming has been accepted by the authors. It would have been a great help to have had the author's naming indicated by initials in the corner of each graph, as, for instance, Li. for limonite. Then again, figure 2 is described as giving " temperature—time dehydration curves ". It appears that each graph in the figure co-ordinates successive temperatures of a hydrate charge with the differences of these temperatures and those of a control body, where both charge and control have been heated in a furnace regulated to raise the control's temperature at a roughly uniform rate. But to make certain of all this one has to turn to previous literature.

E. B. Bailey.

The Channel Islands. By John Parkinson. *Handbuch der regionalen Geologie*, vol. iii, pt. i, pp. 335–41. Heidelberg, 1916.

In Steinmann's *Handbuch der regionalen Geologie*, Mr. John Parkinson gives a clear outline of the Geology of the Channel Islands, a subject to which he made formerly some valuable contributions. It is illustrated by geological sections and small maps of the principal islands. In Jersey the oldest sedimentary rocks are probably Brioverian, and in them are some contemporary volcanic rocks, ending with the remarkable rhyolites of Boulay Bay and Anne Port. Intrusive granites and diorites also occur, the latter being the

older. There are some raised beaches, and a cave has yielded palæoliths of Mousterian age, and nine human teeth of primitive Neanderthal type. Alderney consists of diorite, varying from a very basic form to a tonalite, with a grit (*grès felspathique*) of early Arenig age. Diorite, tonalite, hornblende schist, and banded granulites make up Sark. In Guernsey the southern and larger portion is a somewhat variable gneiss, a pressure-modified more or less porphyritic granite, the oldest rock in the islands, the northern half being variations of diorite—basic, felspathic, and quartzose—together with two small areas of granite. Mr. Parkinson retains the name hornblende gabbro, which was employed by Messrs. Hill and Bonney in their paper on Guernsey in 1884 (Quart. Journ., vol. xl, pp. 410 and 425), but dropped after their work in 1910 (Quart. Journ., vol. lxviii, pp. 32–7) as they found it impossible to separate precisely the varieties of diorite, though convinced that some of them, at any rate, had once been augitic rocks. Dyke rocks occur in all the islands, and in some mica-traps are rather abundant. These are post-Arenig, and the greenstone, though rather older, is probably the same. Microgranites are also found, some of which seem to be post-Cambrian. The diorites, however, are probably pre-Cambrian, and form a very interesting group of associated rocks. As might be expected from their geographical position, the sedimentary and some of the igneous rocks of these islands are nearly related to those of the adjacent mainland of France, but the hornblende schists and granulites of Sark are often indistinguishable from corresponding rocks at the Lizard.

Australian Antarctic Expedition, 1911–14: Scientific Reports. Series C, Vol. IV, pt. iii: Brachiopoda. By J. Allan Thomson. With 4 plates and 1 map. June, 1918.

PART I of this memoir gives a systematic description of the Brachiopods obtained by the Australian Antarctic Expedition, preceded by an account of what is known of the spicules of calcite found in the body-wall and other parts, together with some remarks on the punctation of the shell. Sixteen species are described, and are referred to the genera *Crania*, *Hemithyris*, *Liothyrella*, *Amphithyris* (gen. nov.), *Stethothyris*, *Gyrothyris*, *Magellania*, *Terebratella*, and *Macandrevia*.

Part II deals with the geographical distribution of the Brachiopods of the Southern Seas. Twenty geographical districts are recognized in the part of the sea-floor above the 1,000 fathom line, but in half of these no Brachiopods have yet been found, so that future discoveries may necessitate modifications in the conclusions drawn from the distribution of the small number of species at present known. Only one species is common to two of these geographical districts; all the other species are confined to single districts.

The author points out the resemblance between the recent

Brachiopod faunas of these districts and the fossil faunas found in the Upper Tertiary of the neighbouring lands. Thus the recent New Zealand fauna is a diminished representative of the Oamaruian fauna; the recent Australian fauna (excepting the subtropical part on the north-east coast) is a remnant of the Australian Miocene fauna of that continent. The Antarctic recent fauna is least like the Tertiary fauna of that district, owing to the presence of recent northern immigrants (*Macandrevia*, *Frieleia*, *Magellania* s.str.). The author concludes that the distribution of the recent brachiopods in the Southern Seas is explained by the ancestral distribution in the Miocene period, and that it calls for no shallow-water connexions between the various southern continents and islands since that date, except perhaps between South America and the Antarctic.

On the other hand, the resemblances between the Oligocene–Miocene faunas of the four regions named indicate the existence at an earlier date of greater means of communication between the lands bordering the Southern Pacific Ocean than exists at the present day.

The genera *Argyrotheca*, *Amphithyris*, *Kraussina*, and *Megerlina* are found in the New Zealand and Australian districts, but not in the Antarctic and South American; as these genera occur also in the Indian Ocean and the Mediterranean the author suggests that Australia had former connexions with South Africa and the Mediterranean. Dr. Thomson states that the molluscan faunas of the Patagonian of South America and the Oamaruian of New Zealand give evidence of a much warmer climate than is found at present in these regions. The occurrence of some species and genera of Brachiopods in the Oligocene–Miocene of the Antarctic which are also found in the Patagonian, the Oamaruian, and the "Miocene" of Australia suggests a warmer climate for the Antarctic seas of that period.

The author urges the desirability of further dredging on the submarine banks of the Southern and Pacific Oceans; if these banks are due to the sinking of land masses the remains of coastal faunas should be found on them. The concluding pages of the work give a brief account of the diastrophic history of New Zealand. The map of the Antarctic and Southern Oceans shows the 1,000 and 2,000 fathom contours.

PETROLOGY FOR STUDENTS. By ALFRED HARKER, M.A., LL.D., F.R.S., F.G.S. 5th edition, revised. pp. 300, with 100 figures. Cambridge University Press, 1919. Price 8*s*. 6*d*. net.

DR. HARKER has been enabled during the comparative freedom from the burden of teaching afforded by the War to prepare a fifth and further revised edition of his standard textbook of petrology, which is too well known to require a detailed notice here. Considerable parts of the work have been rewritten, and the results of all important recent work is incorporated. The author

has made use of the work of British petrologists since the issue of the fourth edition in 1908, and has found it possible to illustrate most of the important rock-types by examples drawn from home and from the British Empire. Besides new material there is a certain amount of rearrangement, noticeable especially in the chapters on nepheline-syenites and phonolites and in the section devoted to metamorphism. A number of new figures have been added, bringing the total to 100. These are a most useful feature of the book, and it is unfortunate that some of them have been printed off for this edition in a manner that fails to do justice to the beauty of the original drawings. We are glad to observe that Dr. Harker's book is still sold at a price that brings it within the reach of every student, while to the advanced worker it is equally valuable as a work of reference and standard authority on its subject.

Palæontology (Invertebrate). By H. Woods, M.A., F.R.S. 5th edition. pp. 411, with 173 figures. Cambridge University Press, 1919. Price 12*s.* 6*d.* net.

Although this fifth edition of Mr. Woods's book is apparently smaller than the last, it actually contains 23 more pages and 24 fresh figures. It has been revised throughout, additions and modifications being made in most parts of the work. The section on the Asterozoa has been to a large extent rewritten, so as to bring it into accordance with the recent work of Dr. W. K. Spencer on Palæozoic starfishes. A revised account is given of the distribution of marine mollusca at the present day. In the section devoted to the Trilobites account is taken of the recent work of Walcott on the appendages and of Ruedemann on the median eye. The account of the Malacostraca has been amplified, and the classification of Calman and other recent writers adopted. The work of revision must have been difficult owing to the extensive additions to the literature of almost every group of invertebrates since the appearance of the fourth edition, and the author is to be congratulated on the successful manner in which he has dealt with this. It is to be regretted that enhanced cost of production has made such a considerable increase in the price necessary, since some students of geology may thereby be deterred from buying this indispensable work.

REPORTS AND PROCEEDINGS.

Geological Society of London.

November 19, 1919.—Mr. G. W. Lamplugh, F.R.S., President, in the chair.

The following communication was read: "The Pleistocene Deposits around Cambridge." By Prof. John Edward Marr, Sc.D., F.R.S., V.P.G.S.

This paper deals with the deposits in the immediate vicinity of Cambridge, and contains new records of sections, fossils, and implements. It is pointed out that owing to alternating periods of erosion and aggradation, relative height above sea-level is not a trustworthy index of antiquity, and modifications of the classification proposed by W. Penning and A. J. Jukes-Browne are indicated.

The author suggests the following chronological sequence, in descending order :—

		Feet.
1.	Barnwell Station Beds	20
2.	Newer Downing Site Beds	35
3.	Newer Barnwell Village Beds	45
4.	Huntingdon Road Clays	70
5.	Observatory Beds	85
6.	*Corbicula* Gravels (Barnwell village, etc.) . .	30

The figures on the right give the approximate height above sea-level.

It is believed that Nos. 6 and 5 were formed during a period of aggradation, and 4–1 during one of subsequent erosion with minor aggradation ; but it cannot be conclusively proved that 6 and 3 are of different ages, although the deposition of the beds 6 below those of series 3, where they occur together, and the occurrence of *Hippopotamus* and *Belgrandia marginata* with *Corbicula* suggest an early date for these *Corbicula*-bearing beds.

Taking the beds in the order of reputed age, the following observations are noted :—

Chellean implements have been found at low levels at Barnwell and Chesterton, and may belong to beds 1. The Observatory Beds have yielded abundant implements of Chellean, Acheulean, and early Mousterian types, the last-named apparently in deposits later than those containing the two first-named. Unfortunately mollusca and mammalia are very rare in these beds. The Huntingdon Road Clays require further work, as only poor exposures have hitherto been found, and it is not clear that they are newer than the Observatory Beds.

The beds referred to the Newer Barnwell Village Series contain abundant remains of the mammoth, woolly rhinoceros, and fairly numerous horse-bones. Implements associated with them suggest an Upper Palæolithic age.

The Newer Downing Site Beds have yielded a cold molluscan fauna. They are probably somewhat earlier than the Barnwell Station Series, which has furnished a similar molluscan fauna, and also an Arctic flora, the plants of which were identified by the late Mr. Clement Reid. Reindeer occurs in these beds.

The paper is chiefly a record of facts, but it is intended to be preliminary to a detailed survey of the Pleistocene deposits of the Great Ouse Basin, which are so important as throwing light upon the relationship of the Palæolithic beds to the glacial accumulations, and also to the marine beds of March and the Nar Valley.

Appendix I, on the Non-Marine Mollusca, is supplied by A. S. Kennard, F.G.S., and B. B. Woodward, F.L.S., F.G.S.

Lists are given of the non-marine mollusca from the various sections, with their degrees of frequency. These lists are based on examination of old collections and on a large amount of new material. Notes are appended on some of the species, and conclusions as to the ages of the Cambridge gravels are given, based on the molluscan evidence.

Appendix II, on the Implements, is supplied by Miles C. Burkitt, M.A.

Geologists' Association.

December 5, 1919.

The following lecture was delivered: "Geological Work on the Western Front." By W. B. R. King, B.A., F.G.S.

A short description was given of the geology of that part of Belgium and France over which military operations were conducted by the British armies between 1915 and the summer of 1918.

It was mainly confined to the lithological divisions and did not deal with the palæontological side of the subject. The main physical features were taken, showing how they are connected with the geological structure.

The effect of the geology and the geological structure on certain questions of military operations were dealt with, notably with regard to water supply and military mining and dug-out construction. Particular attention was paid to the problem of obtaining water from boreholes in the Landenien (Thanet) Sands, the causes and effect of the seasonal variation of water-level in the Chalk, and the problem of the military mines near Messines, Givenchy-les-la-Bassée, and Souchez.

The lecture ended with a description of certain maps which were prepared for the armies in France, and notes on several other problems which had to be dealt with by the geologists attached to General Headquarters.

Liverpool Geological Society.

November 11, 1919.—W. T. Walker, Esq., B.Sc., F.G.S., President, in the chair.

The following communications were read: "The Contribution of a local Geological Society to a Regional Survey." "Marl and Marling in Cheshire." By William Hewitt, B.Sc.

The idea of a fairly complete systematic survey of a district—comprising its physiographical and geological features, its climatic record, its botanical and zoological population and distribution, its ethnographical and archæological history, its agricultural and industrial conditions and their evolution—as the basis of a carefully planned scheme of development for the district as a whole,

has received considerable attention in recent years, largely owing to the persistent advocacy of Professor Patrick Geddes. The recent establishment of a Regional Survey Association for the Liverpool district, initiated by Professor P. M. Roxby, and the progress already made in connexion with the survey of the peninsula of Wirral—the first piece of work undertaken by that Association—is well known, and the object of the first communication was to suggest that the geological section of such a survey was one that might well be taken in hand by a local Geological Society and worked systematically by the Society as a body in accordance with a carefully planned scheme of investigation and record. A list of problems for investigation and record was submitted and elaborated, including: Coast erosion and changes, reclamation of land from the sea, records or indications of changes of relative level of land and sea in geologically recent times, natural drainage systems, existing stone-quarries and brickfields, and distribution of other commercially valuable mineral substances, nature and character of the soil and subsoil, etc.

The second communication served as a practical illustration of the nature of the investigations which might be undertaken, and embodied much useful and interesting information concerning marl and the extensive marling of the land in Cheshire in past days.

Following the reading of the papers, Professor Roxby gave an account of the work which has already been done in Wirral, and exhibited a series of maps on which the information thus far collected has been expressed; after which Professor Boswell, who has been appointed director of the geological and physiographical section of the survey, dealt more particularly with some of the investigations which awaited attention, among which a survey of the soil was one of the most important and pressing.

CORRESPONDENCE.

BRACHIOPOD NOMENCLATURE: *SPIRIFER* AND *SYRINGOTHYRIS*.

Sir,—In my paper on the above subject in the August number of the Geological Magazine, pp. 371–4, the dates of publication of the genus *Spirifer* by Sowerby were left in doubt. Mr. C. Davies Sherborn has kindly informed me that the paper read to the Linnean Society was published in Trans. Linn. Soc., vol. xii, pt. ii, p. 515, in September or October, 1819 (see Trans. Geol. Soc., vol. v, p. 633, under List of Donations). *Min. Conch.*, vol. ii, No. 21, was published in February, 1816 (see Bull. Soc. Vaudoise, 1855). The genus *Spirifer* was therefore first published in 1816, with sole species *Spirifer cuspidatus*, and my argument holds good.

With regard to *Ichthyosaurus*, however, it appears that Flower and Lydekker did not go fully into the matter, for it was proposed